

# CIRCUS - Circular use of plastic in the automotive industry

Public report, RISE 2026:32  
ISBN 978-91-90109-60-1



Project within Automotive research and innovation program, Circularity

Author Annika Boss, Birgit Brunklaus, Fredrik Bergfeldt and Alexander Wahlberg  
Date 2026-03-24



Fordonstrategisk  
Forskning och  
Innovation

## Content

<b>Summary</b> .....	<b>3</b>
<b>Sammanfattning på svenska</b> .....	<b>5</b>
<b>1. Background</b> .....	<b>6</b>
<b>2. Purpose, research questions and method</b> .....	<b>7</b>
Purpose and research questions.....	7
Methods and project implementation.....	7
<b>3. Objective</b> .....	<b>9</b>
<b>4. Performance, results and conclusions</b> .....	<b>10</b>
Pre-study – Handling of ELV vehicles and automotive plastics (WP1) .....	10
Dismantling plastic components (WP 2).....	18
Preparation and characterization of ELV recyclates (WP 3) .....	37
Re-design for circularity (WP 4).....	45
Recycling system and business model (WP 5).....	55
Environmental system analysis (WP 6) .....	57
<b>5. Deliverables and contribution to the goals</b> .....	<b>61</b>
<b>6. Dissemination and publications</b> .....	<b>63</b>
1.1 Dissemination activities .....	63
1.2 Publications.....	63
<b>7. Conclusions and future research</b> .....	<b>64</b>
<b>8. Participating parties and contact persons</b> .....	<b>67</b>

### FFI in short

FFI, Strategic Vehicle Research and Innovation, is a joint program between the state and the automotive industry running since 2009. FFI promotes and finances research and innovation to sustainable road transport.

For more information: [www.ffisweden.se](http://www.ffisweden.se)

## Summary

Plastics account for approximately 10–15% of a vehicle's weight, yet despite this material value, only a small share of plastics from end-of-life vehicles (ELVs) is currently recycled in Sweden. Today, the majority of ELV plastics are sent to energy recovery or landfill. The forthcoming ELV regulation will introduce stricter requirements for recycled content in new vehicles, increasing the need for effective methods for dismantling, sorting, and upgrading ELV-based plastic materials.

The CIRCUS project aimed to develop knowledge, methods, and system solutions that enable circular material flows of automotive plastics — from dismantling and material processing to design, business models, and environmental analysis.

The project included practical dismantling studies on vehicles of different ages, material characterisation and compounding of recycled plastic fractions, the development of pick lists and sorting routines, redesign proposals to support circularity, as well as system, business, and environmental analyses of future circular value chains. The work was carried out across the entire value chain in close collaboration between OEMs, dismantlers, recyclers, material producers, and component manufacturers.

The results show that a significant share of today's plastic components can be dismantled efficiently using existing workshop routines and that several plastic types (e.g., PP, ABS, PC/ABS) are technically suitable for mechanical recycling. Model-specific pick lists and standardised routines for dismantling, cleaning, and sorting were developed and tested. Material studies demonstrate that recycled ELV plastic fractions can be compounded into material blends with properties that in many cases approach the requirements for automotive applications. At the same time, bottlenecks were identified in washing, paint removal, homogenisation, and melt filtration, all of which require further development.

The project also developed recommendations for circular design and demonstrated how business models, logistics, and cost structures need to be adapted to enable circular plastic flows. The environmental analysis confirms that recycling ELV plastics can reduce climate impact both by avoiding incineration and by replacing virgin polymers.

The CIRCUS project shows that Sweden has strong potential to establish circular value chains for ELV plastics, but further development is required in several areas:

- robust and scalable methods for washing, sorting, and material upgrading

- long-term testing and pilot production to verify material performance in automotive components
- business models, incentives, and logistics solutions adapted to circular flows
- clear requirements and design strategies for future vehicle components
- broader national collaboration between OEMs, dismantlers, recyclers, and material suppliers

The results of the project directly support the industry's preparations for the upcoming ELV regulation and represent an important step toward high-quality circular use of plastics in future vehicles.

## Sammanfattning på svenska

Plast står för cirka 10–15 % av ett fordonets vikt, men trots detta materialvärde återvinns endast en liten andel av plasten från uttjänta fordon (ELV) i Sverige. I dag går majoriteten av ELV-plasterna till energiutvinning eller deponi. Den kommande ELV-förordningen skärper kraven på återvunnet innehåll i nya fordon och ökar behovet av effektiva metoder för demontering, sortering och uppgradering av ELV-baserade plastmaterial.

CIRCUS-projektet syftade till att skapa kunskap, metoder och systemlösningar som möjliggör cirkulära materialflöden av fordonsplast, från demontering och materialförädling till design, affärsmodeller och miljöanalys.

Projektet omfattade praktiska demonteringsstudier på fordon i olika åldrar, materialkaraktisering och komponering av återvunna plastfraktioner, utveckling av plocklistor och sorteringsrutiner, redesign-förslag för ökad cirkularitet samt system-, affärs- och miljöanalyser av framtida cirkulära värdekedjor. Arbetet genomfördes i hela värdekedjan i nära samarbete mellan OEM:er, demonterare, återvinnare, materialproducenter och komponenttillverkare.

Projektets resultat visar att en betydande del av plastkomponenterna i dagens fordon kan demonteras effektivt med befintliga verkstadsrutiner och att flera plasttyper (t.ex. PP, ABS, PC/ABS) är tekniskt lämpliga för mekanisk återvinning. Modell-specifika plocklistor och standardiserade rutiner för demontering, rengöring och sortering utvecklades och testades. Materialstudierna visar att återvunna ELV-plastfraktioner kan komponeras till materialblandningar med egenskaper som i många fall närmar sig kravbilderna för fordonsapplikationer. Samtidigt identifierades flaskhalsar i tvätt, färgborttagning, homogenisering och smältfiltrering som kräver vidare utveckling. Projektet har även tagit fram rekommendationer för cirkulär design och visat hur affärsmodeller, logistik och kostnadsstrukturer behöver anpassas för att möjliggöra cirkulära plastflöden. Miljöanalysen verifierar att återvinning av ELV-plast kan minska klimatpåverkan både genom att undvika förbränning och genom att ersätta jungfruliga polymerer.

CIRCUS-projektet visar att Sverige har goda förutsättningar att etablera cirkulära värdekedjor för ELV-plaster, men att fortsatt utveckling krävs inom flera områden:

- robusta och skalbara metoder för tvätt, sortering och materialförädling
- långtidstester och pilotproduktion för att verifiera materialens funktion i fordonskomponenter
- affärsmodeller, incitament och logistiklösningar anpassade för cirkulära flöden

- tydliga krav och designstrategier för framtida fordonskomponenter
- bredare nationell samverkan mellan OEM:er, demonterare, återvinnare och materialleverantörer

Projektets resultat bidrar direkt till industrins förberedelser inför den kommande ELV-lagstiftningen och utgör ett viktigt steg mot högkvalitativ cirkulär användning av plast i framtida fordon.

## 1. Background

Plastics play a crucial role in modern vehicles due to their low weight, versatility, and design flexibility, offering significant advantages in terms of performance, safety, and functionality. Plastics represent a substantial share (30–50%) of key components in current and future vehicle safety systems, such as seat belts, airbags, bumpers, and headlights. Vehicle production is therefore highly plastic-intensive. Today, approximately 10% of the total plastic consumption in Europe corresponding to around 6 million tonnes per year is used by the European automotive industry<sup>1</sup>. On average, the plastic content of vehicles is about 150–180 kg per tonne of vehicle weight, meaning that a medium-sized truck contains approximately 500 kg of plastics<sup>2</sup>. The use of plastics in vehicles continues to increase, and almost all automotive plastics are currently produced from fossil-based raw materials.

Incorporating recycled plastics into vehicles is therefore essential for the sustainable transformation of the automotive industry, as it offers significant potential for resource conservation and reduction of greenhouse gas emissions. However, the transition towards circular plastics in vehicles is challenged by stringent quality, safety, and performance requirements, particularly for components used in safety-critical and high-performance applications.

A major driver for change is the forthcoming EU End-of-Life Vehicles (ELV) Regulation. Based on the provisional agreement reached between the European Parliament and the Council on 11–12 December 2025, the new regulation aims to transform the automotive sector towards a circular economy, replacing previous ELV directives<sup>3</sup>. The scope of the regulation is expanded beyond passenger cars to include heavy-duty trucks, buses, motorcycles, and quadricycles. A binding target requires that by 2030, 25% of the plastic content in new vehicles must originate from recycled

---

<sup>1</sup> <https://plasticseurope.org/knowledge-hub/plastics-the-fast-facts-2023/> [the fast F...ics Europe]

<sup>2</sup> [Automotive-Plastics-and-Polymer-Composites-A-Roadmap-for-Future-Mobility.pdf](#)

<sup>3</sup> [ELV-Provisionalagreement-consolidatedtext-FINAL\\_EN.pdf](#)

plastics, of which 20% must come from end-of-life vehicles. Only post-consumer recycled (PCR) plastics will be counted as recycled, while post-industrial recycled plastics will not. Chemically recycled plastics, using a mass-balance approach, will be accepted as recycled content. Bio-based feedstock will also be counted. The regulation is expected to apply two years after final adoption, with certain bans entering into force five years after entry into force. Vehicle producers will be held responsible for the entire life cycle of their vehicles, including end-of-life management. Considering that more than six million vehicles reach their end of life annually in the EU, with large volumes of material currently lost, the regulation represents a fundamental shift in requirements and responsibilities for the automotive industry.

Based on the automotive industry's need for recycled plastics and the new ELV regulation coming the project gathered key actors across the value chain with the goal of creating the necessary conditions for circular recycling of plastic vehicle components.

## **2. Purpose, research questions and method**

### **Purpose and research questions**

The overall purpose of the CIRCUS project was to investigate whether and how the Swedish automotive industry can adapt to and comply with the proposed new End-of-Life Vehicles (ELV) regulation, with a specific focus on plastics. The project aimed to identify technically, economically and environmentally feasible solutions for increased reuse and recycling of plastic components from end-of-life and value cars, while maintaining the quality and performance requirements of the automotive industry.

The project addressed the following research questions:

- Can the Swedish automotive industry meet the requirements of the proposed new ELV regulation?
- Which plastic components from passenger cars are suitable for reuse, and which can be recycled in a technically and cost-efficient manner?
- What is the quality and material performance of plastics recovered from ELV and value cars?
- How should plastic components be designed and constructed to enable efficient reuse and high-quality recycling?

### **Methods and project implementation**

The project was carried out through seven interlinked work packages (WP1–WP7), covering the entire value chain from pre-study and dismantling to material characterization, redesign, business models and environmental system analysis. The work packages were

executed in close collaboration between research institutes, vehicle manufacturers, component suppliers, dismantlers and recyclers.

### ***WP1 Pre-study***

WP1 was led by Karin Lindqvist (RISE) and conducted in collaboration with Volvo Car Corporation, Polestar, Svensk Bilåtervinnings Riksförbund (SBR), Mobility Sweden, Bilretur ABC, Jönköpings Bildemontering, Eklunds Bildelslager i Skövde and Walters Bildelar. The work included literature reviews, desktop studies, interviews with project partners, mapping of ongoing initiatives, and site visits to dismantling facilities to study current handling of vehicles and plastic components. Meetings with Volvo Cars and Polestar were held to identify plastic components with potential for circulation, either through reuse (car-to-car) or material recycling.

### ***WP2 Dismantling of plastic components***

WP2 was led by Fredrik P. Bergfeldt. The main activities were carried out by the dismantlers Jönköpings Bildemontering, Eklunds Bildelslager and Walters Bildelar, in collaboration with RISE, Volvo Cars, Polestar, Stena Recycling and MOCOM/WIPAG. The work included planning and execution of dismantling trials on value cars and ELV vehicles from Volvo, Polestar and additional brands. Dismantling efficiency, time studies, component condition and practical challenges were documented. Components selected for redesign in WP4 were also dismantled and evaluated.

### ***WP3 Characterisation of components and materials***

WP3 was led by Annika Boss (RISE) and performed together with MOCOM/WIPAG, RondoPlast, IAC, Plasman, KB Components, Volvo Cars and Polestar. The work included evaluation of reused components from value cars, as well as detailed material characterisation of plastics recovered from ELV and value cars. Material properties, purity, processability and degradation were analysed.

### ***WP4 Redesign for circularity***

WP4 was led by Marcus Schill (Plasman) and performed mainly by IAC, Plasman, KB Components, MOCOM and RISE, with contributions from Volvo Cars, Polestar and Stena Recycling. Three component systems were selected for redesign studies. Material choices, component construction and recycling feasibility were analysed. MOCOM conducted technical and economic recycling feasibility studies based on existing industrial processes. Redesign proposals and construction guidelines were developed to enable mechanical recycling. In parallel, international standardisation work was carried out through EGARA and SIS technical committee SIS/TK 156/AG04, contributing to the development of the technical specification “Road vehicles – Post Shredder Technology recycling – Design recommendations for plastic products” within the Circular Plastics Alliance.

### ***WP5 Business models***

WP5 was led by Alexander Wahlberg (RISE) and involved all project partners. Based on workshops and interviews, value chains and material flows for plastic components were mapped. Collaboration models between actors were analysed, and costs and economic feasibility for dismantling, collection and recycling of automotive plastic components were assessed. The potential economic impact of the new ELV regulation on the Swedish automotive industry, dismantlers and recyclers was evaluated.

### ***WP6 Environmental system analysis***

WP6 was led by Birgit Brunklaus (RISE). Environmental system analyses and life cycle assessments (LCA) were performed based on results from WP4 and WP5. The environmental impacts were assessed per plastic type, per component and per vehicle, and compared for different reuse and recycling scenarios. The results were linked to future regulatory requirements, including the proposed ELV regulation, and assessed for both the Volvo car fleet and the Swedish vehicle fleet.

## **3. Objective**

Based on the automotive industry's increasing need for high-quality recycled plastics and the requirements of the 2023 End-of-Life Vehicles (ELV) Regulation, the project brought together key actors across the automotive value chain with the shared objective of creating the conditions for closed-loop recycling of automotive plastics. By addressing the specific objectives outlined below, the project generated knowledge, methods and practical experience that can be implemented and scaled up, thereby enabling material recycling of plastics into new automotive components.

The project objectives were to:

- Identify which plastic components (based on the selected sample) are best suited for dismantling and material recycling, and to characterise the properties and quality of the recovered plastics.
- Identify which plastic components are best suited for dismantling and reuse. This objective was deprioritised during the project, as component reuse is already a well-established, market-driven practice, strongly supported by insurance companies and existing business models.
- Propose redesign concepts for three components or component systems that enable either component reuse or mechanical recycling of the plastic material, achieving a minimum recycling rate of 80%.

- Demonstrate the requirements—regarding recycling rates and the availability of recycled feedstock of appropriate type and quality—for the Swedish automotive industry to comply with the proposed ELV Regulation published in July 2023.
- Perform techno-economic analyses of circular recycling system options for automotive plastics and propose viable business models.
- Quantify the potential environmental benefits of the proposed recycling and reuse options.
- Contribute in the long term to a sustainable and competitive Swedish automotive industry, with a target of at least 25% closed-loop recycling of automotive plastics by 2030.

## 4. Performance, results and conclusions

In this session “performance, results and conclusions” of each part of the project (work packages) are compiled.

### Pre-study – Handling of ELV vehicles and automotive plastics (WP1)

#### Background and context (Sweden)

Each year, approximately 160,000–180,000 end-of-life vehicles (ELVs) are treated in Sweden. Plastics account for roughly 20% of a vehicle by volume, and the polymer share in modern vehicles continues to increase. In parallel, a substantial number of vehicles are involved in accidents annually (approximately 600,000), resulting in repairs and replacement of parts. Under the Swedish producer responsibility framework, ELVs must reach an overall recovery rate of at least 95%. While metal recycling from ELVs is well established and has been industrially implemented for decades, plastics from ELVs have historically been recovered mainly as energy (i.e., incinerated).

In 2022, close to 160,000 vehicles were scrapped in Sweden, with an average scrappage age of approximately 19 years [3]. This corresponds to an estimated 24.6 kt of plastic arising from scrapped vehicles, where most plastics currently follow the car body into shredding/fragmentation.

#### Definitions: “value cars” and ELVs

Damaged vehicles that are fully insured are commonly referred to as *value cars* (insurance vehicles). These vehicles are typically not older than ten years, although no strict definition exists; decisions are made by insurance companies regarding whether a damaged vehicle should be repaired, where repairs should be carried out, or whether the vehicle should be

transferred to a dismantler. Insurance companies may also specify which parts should be removed for reuse. Vehicles that are not repaired ultimately become ELVs. In Sweden, ELVs are generally shredded, and the average ELV age (approximately 19 years) is high compared with several Western European countries.

For clarity in this report, a damaged vehicle may be described as a vehicle within the last ten model years that has suffered collision damage or similar events to the extent that the estimated repair cost for safe road operation exceeds 60% of the vehicle's fair market value immediately prior to damage. Repair cost estimates typically focus on safety-critical components (e.g., suspension, engine, transmission, frame/unibody and designated structural components). If deemed unrepairable, the vehicle is transported to a dismantler and handled as ELV/hazardous waste until decontamination.

### **Handling of damaged cars and ELV's**

The handling of cars and the plastics was examined through site visits to three dismantling facilities: Jönköpings Bildemontering, Eklunds Bildelslager i Skövde and Walters Bildelar.

For damaged vehicles, salvage is followed by a decision on repairability. Repair costs are typically estimated by a workshop, after which the insurance company decides whether the vehicle will be repaired or not. If a vehicle is deemed unrepairable, it is transported to a dismantler and labelled as ELV (hazardous waste) until decontamination.

Upon arrival at the dismantler, vehicles and selected components may be tested to assess potential for reuse. Vehicles then undergo *decontamination*, meaning removal of liquids and hazardous components. The following items are typically removed (Figure 2):

Oils and oil filters, fuel, other liquids, capacitors and filters containing PCB or PCT, refrigerant from AC systems, starter battery, traction battery in electric vehicles, components containing mercury, lead-containing components (where applicable), liquefied gas tanks, potentially explosive components (e.g., airbags), catalysts, windscreen glass, metal components containing copper, aluminium or magnesium (unless separated in shredding), tyres and large plastic parts (unless separated during shredding in a way enabling effective material recycling)

After decontamination, the vehicle is typically reclassified under EWC code 16 01 06, denoting ELVs containing neither liquids nor hazardous components, classified as *absolute non-hazardous waste*. The vehicle is deregistered, compacted and sent to fragmentation for downstream materials recovery. However, if testing prior to decontamination identifies parts with reuse potential, these components are removed according to a dismantling list (a "dismantling order"), enabling their use as spare parts to repair other vehicles.

## **Handling of parts for reuse: traceability and logistics**

For dismantlers handling value cars, a central activity is execution of the dismantling order, i.e. order for systematic removal of components for reuse. Parts are removed carefully, photographed, assigned barcodes, and registered in databases together with storage locations to enable traceability. The information is linked to vehicle model and production year. Reused parts are sold to workshops or private customers.

Repair workshops frequently place orders through systems such as CABAS, enabling dismantlers to respond to requests and supply parts. CABAS is also used in repair cost estimation; consequently, required parts may already be identified during the initial repairability assessment.

## **Observations from the dismantling site visits**

### ***Eklunds Bildelslager (Skövde)***

Eklunds is one of the largest dismantlers in Sweden. Approximately 3500 cars/year are dismantled by about 34 employees. Dismantling is mainly manually performed but Eklunds uses also a “power grip” to remove components like the cable harnesses. The facility has in-house compaction equipment for car bodies and dedicated transport for collecting damaged vehicles. Plastics are currently largely left in the car body.

### ***Jönköpings Bildemontering (JB)***

JB dismantles approximately 2 300 cars/year, where 75–80% are Volvo vehicles. JB operates its own vehicle collection and supplies spare parts to around 30 repair workshops. JB has initiated collection of PP components for recycling through collaboration with Stena Recycling.

### ***Walters Bildelar***

Walters dismantles approximately 2 000 cars/year and is a brand dismantler for VAG. Walters has also a power grip to remove the cable harnesses and it operates compaction equipment for car bodies. The facility uses a closed system for handling fluids removed during dismantling, contributing to improved work environment conditions. Walters also uses a production planning tool to match staff and dismantling tasks and to track throughput and inventory status.

All three dismantlers have large spare part warehousing and reports that the reuse business functions works effectively due to strong market demand. Insurance companies commonly require reused parts for older vehicles (e.g., >5 years), once certain guarantees no longer apply. During the pandemic, demand for reused parts reportedly increased by approximately 30%, and stakeholders indicate that demand is increasing.



Figure 1. Visit at dismantling site.



Figure 2. Examples from site visits and handling practices. Jönköpings Bildemontering has started to sort out parts of PP plastic. Eklunds and Walters dismantle the cable harnesses using a power grip.

### Summary dismantling management in Sweden

- Sweden has approximately 200 dismantlers, many of which are small organisations primarily handling older ELVs distributed across the country.
- Reuse of components from value cars (including plastics where applicable) operates effectively due to market demand and insurance-driven incentives, contributing to extended vehicle life and improved resource efficiency.
- Dismantlers generally remove parts that are requested by the market; additional plastic components are not typically proposed beyond this demand-driven selection (“we dismantle everything that we can sell”).

- Some vehicles that could technically be repaired may nevertheless be classified as ELVs due to repair cost calculations.
- Material recycling of plastics from ELVs is not established in Sweden; most plastics follow the car body into fragmentation and end up in shredder light fraction (SLF), which is primarily sent to energy recovery.

### **Handling ELV's in Europe**

Across Europe, approximately six million end-of-life vehicles (ELVs) are dismantled each year, generating substantial quantities of metal, plastics, and rubber. The current recovery rate for plastic parts from ELVs in the EU is around 19 percent.

The recovery of plastic The low recycling rate is due to problems with separating and cleaning the plastic fractions from end-of-life vehicles and a lack of robust recycling value chains<sup>4</sup>.

European countries apply different systems and policy measures to improve ELV handling. Norway is in the process of implementing an approach similar to Sweden's, including mandatory insurance schemes, while Denmark is also adopting elements of the Swedish model. Finland uses a system comparable to CABAS, known as DELV. In France, legislation requires workshops to consider the use of reused parts when repairing vehicles.

A significant number of damaged vehicles are sold at auctions across Europe. Some of these vehicles qualify as ELVs. Many old vehicles are exported to Eastern Europe, often originating from Germany. At the same time, large numbers of end-of-use vehicles leak out of Europe every year, which represents a growing concern. Many of the ELVs leaving the EU are exported illegally, particularly to Africa. In several European countries, workshops also carry out dismantling operations, meaning that repairs and vehicle disassembly are often integrated within the same business structure.

In Europe, there are a few companies that plays a central role in recycling plastics from ELVs. It is Axion Polymers and MBA Polymers in the United Kingdom and Galloo Plastics in France. Also, MOCOM in Germany processes vehicle plastics such as bumpers and produces recycled plastic compounds for the automotive industry. Unfortunately, MOCOM is planning to sell their recycling site in Germany due to economic challenges.

---

<sup>4</sup> [Accelerating the recycling of automotive plastics - Danish Technological Institute](#)

### **Initiatives to increase the recycling of automotive plastics**

A major driver for change is the forthcoming EU End-of-Life Vehicles (ELV) Regulation. Based on the provisional agreement reached between the European Parliament and the Council on 11–12 December 2025, the new regulation aims to transform the automotive sector towards a circular economy, replacing previous ELV directives<sup>5</sup>. The scope of the regulation is expanded beyond passenger cars to include heavy-duty trucks, buses, motorcycles, and quadricycles. A binding target requires that by 2030, 25% of the plastic content in new vehicles must originate from recycled plastics, of which 20% must come from end-of-life vehicles. Only post-consumer recycled (PCR) plastics will be counted as recycled, while post-industrial recycled plastics will not. Chemically recycled plastics, using a mass-balance approach, will be accepted as recycled content. The regulation is expected to apply two years after final adoption, with certain bans entering into force five years after entry into force. Vehicle producers will be held responsible for the entire life cycle of their vehicles, including end-of-life management.

Considering that more than six million vehicles reach their end of life annually in the EU, with large volumes of material currently lost, the regulation represents a fundamental shift in requirements and responsibilities for the automotive industry.

A central question addressed in the project is whether the Swedish automotive industry can meet the upcoming ELV regulation requirements to recycle 30% of plastics from each ELV vehicle and to use 6.25% circular recycled plastics in new vehicles. The analysis indicates that achieving a 30% recycling rate might be possible but meeting the requirement for ELV-based recycled plastic in all new vehicles produced in Sweden is unlikely if the recycled material is limited to ELV vehicles scrapped domestically. In 2024, approximately 160,000 cars were scrapped in Sweden, corresponding to about 4,800 tonnes of recoverable plastic if 30 kg per vehicle is assumed. In comparison, Volvo Cars alone produced 456 250 vehicles in Sweden and 708 716 vehicles globally in 2023, requiring approximately 7 118 tonnes of circular recycled plastics for Swedish production and 11 056 tonnes globally.

**In Sweden** the reuse of spare parts is driven by the market and insurance companies. Mechanical recycling of plastic from cars is still not implemented in Sweden. Most of the plastic from scrapped cars today follows the car body into the fragmentation plant. The plastic is sorted out after the metals come out, as so-called SLF (shredder light fraction). Today, this fraction is mainly sent for incineration with energy extraction.

Recycled plastics are used in some car components today, mostly the recycled plastics used are post-industrial-recycled (PIR) but some of the plastics used are PCR.

---

<sup>5</sup> [ELV-Provisionalagreement-consolidatedtext-FINAL\\_EN.pdf](#)

**In Europe** about 2.9 % of the plastic in vehicles was recycled from PCR plastic today. Several initiatives to increase the recycling are underway in Europe.

Leading automotive manufacturers are investing in circular solutions. A recent example is Toyota Motor Europe (TME), which has announced the establishment of a Toyota Circular Factory at its Burnaston plant in the UK, aimed at processing end-of-life vehicles to recycle, repurpose, and remanufacture components and materials<sup>6</sup>. Similarly, BMW Group has entered a strategic cooperation with PreZero to develop circular business models for ELV recycling and to establish closed material loops across the European automotive industry<sup>7</sup>. These initiatives demonstrate a industrial commitment to circularity, while also highlighting the need for scalable, technically robust, and economically viable solutions.

### **Plastics selected for circular recycling**

The following materials were identified by the project partners to be prioritised for circular recycling: PP, glass-filled PP, EPP, PC/ABS and ABS. These materials were considered particularly relevant based on their prevalence in vehicles and their technical suitability for mechanical recycling.

PP-based plastics are the most widely used polymers in cars, and both Volvo Cars and Polestar intend to further increase their use. PP is comparatively easy to recycle without significant loss of material properties, has a lower environmental footprint during production than many alternative polymers, and is relatively inexpensive. PC/ABS has become a common material in modern vehicles due to its high impact strength and heat resistance, making it suitable for components subjected to demanding performance requirements. In vehicles older than ten years, however, PC/ABS is rare; these cars typically contain ABS instead. Although ABS is no longer commonly used in new Volvo or Polestar models, large volumes are still present in ELVs, making ABS an important candidate for future recycling efforts.

Polestar also highlighted PA and PUR as potentially interesting for circular use. PA is used in airbags and other components requiring high performance and high temperature resistance. However, recycling PA is challenging due to additives and the complex formulations used in these applications. PUR is used extensively in seat foams and other cushioning materials, but its recycling remains technically difficult. For these reasons, PA and PUR were not included in the scope of the project.

---

<sup>6</sup> [Toyota Circular Factory to maximise recycling of ELVs](#)

<sup>7</sup> [BMW Group partners with PreZero to advance circular economy](#)

An ongoing project in Denmark called RACE is studying chemical recycling of seat foams<sup>8</sup>.

Several trends in the automotive industry are expected to influence the future potential for circular recycling of plastics. One important development is the shift toward using fewer types of polymers, with an increasing emphasis on PP-based materials due to their low density, lower carbon footprint, and greater recyclability compared with many other plastics used in vehicles. In many applications, fibres are added to reinforce the material. Both glass fibres and natural fibres are used, and natural fibres such as flax and kenaf are becoming more common because they offer strength, low weight and favourable environmental performance. Other natural fibres, such as hemp and jute, are available as well, but tend to be used less frequently in interior components due to odour challenges. While fibre reinforcement enhances mechanical performance, it also complicates recycling, as fibre-reinforced plastics are more difficult to mechanically recover.

Material trends have also shifted over time. ABS was widely used in vehicles older than ten years, whereas PC/ABS has become more common in modern cars because of its superior impact strength and thermal resistance. To improve impact resistance in PP components, fibre reinforcement is often added. In parallel, PET felt materials have become increasingly prevalent in recent years due to their low weight, ease of processing, and favourable tactile properties; however, their mechanical recycling is challenging and remains a barrier to circular use.

### **Components selected for dismantling**

The selection of plastic components for dismantling was carried out in dialogue between Volvo Cars, Polestar and the dismantlers. Since the primary objective is to enable circular recycling of plastics back into new vehicles, Volvo Cars and Polestar proposed the plastics having strong potential for future application in vehicle. The availability of these plastics in ELV vehicles, as well as their recyclability, were key factors in the selection process.

In addition to material suitability and recycling potential, the selection was balanced against practical dismantling considerations, such as accessibility and required dismantling time. Since the average age of ELVs in Sweden is approximately 19 years, it was decided to dismantle 20 year old vehicles, together with 10 years old vehicles. Preliminary components proposed for dismantling includes: bumpers (PP-EPDM), sill mouldings (PP-EPDM exterior; ABS interior), pillar panels (ABS interior), air guides (PP), door trim mouldings (PP-EPDM), wheel arch liners (PP-talc), wheel arch extenders (PP-EPDM), and load floor supports (PC/ABS interior) etc. The selected components to dismantle are compiled in the next section “Dismantling of plastic components (WP2)”.

---

<sup>8</sup> <https://www.dti.dk/services/accelerating-the-recycling-of-automotive-plastics/46177>

## Dismantling plastic components (WP 2)

### Performance

Manual dismantling of plastic components was carried out in operational dismantling workshops at Jönköpings Bildemontering, Walters Bildelar, and Eklunds Bildelslager. Components were selected based on plastic volume, polymer type, cleanliness, and their potential for circular material recovery.

Dismantling time and component weight were recorded, as well as cleaning time and the resulting cleaned weight. A dismantlability index was calculated to assess efficiency (kg/min). Experiences from the dismantling trials were systematically documented, including which work methods and tools proved most effective. Improvement proposals were developed jointly during the dismantling sessions and further refined during project and planning meetings.



Figure 3. Plastic weight, dismantling and cleaning time was measured.

Manual dismantling offers several advantages: it can be integrated into existing dismantling processes without requiring new technology, it enables the extraction of sorted, high-quality material streams suitable for new plastic feedstock, and it allows flexible selection and sorting based on component condition. However, manual dismantling also requires personnel resources, which results in direct costs. High dismantling and sorting efficiency is therefore essential. A standardised, clear and simple add-on process is needed to minimise handling time and ensure smooth integration into existing dismantling workflows.



Figure 4. The dismantlers have large warehouses of vehicle parts for re-use.

IDIS, the International Dismantling Information System, has been developed by the automotive industry to meet legal requirements related to end-of-life vehicles in countries with such legislation. The system provides basic information on components, materials, and recycling of plastic parts from vehicles.

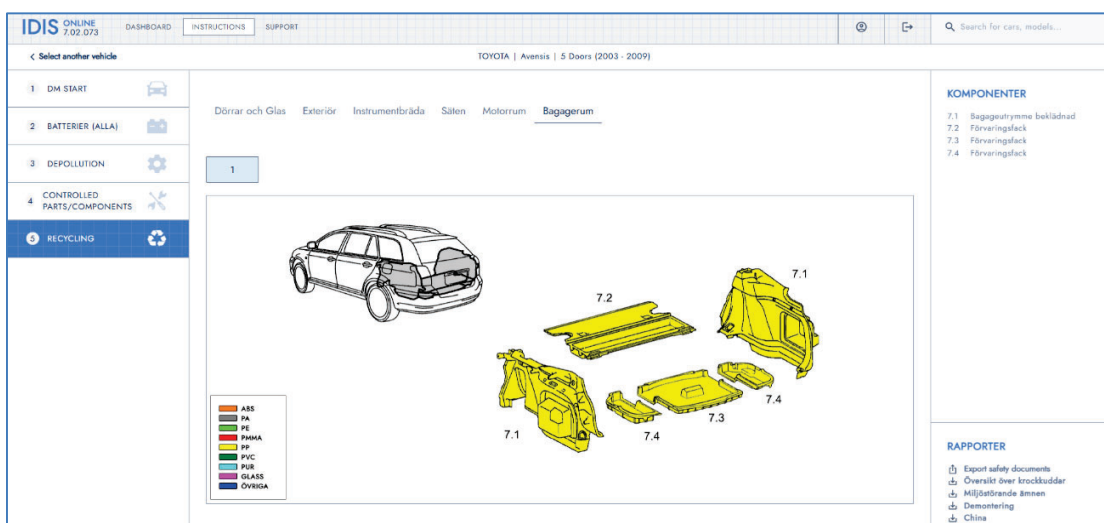


Figure 5. Image from the IDIS system.

The selection of components can be divided into three main categories:

1. Exterior Plastics (Figure 6 and 7)
  - Front and rear bumpers.
  - Protective connecting panels above and below bumpers.
  - Plastic components in the engine compartment.
  - Front and rear wheel arch liners
  - Door moldings, sill trims, kick plates
2. Interior Plastics – Cabin
  - Panels and covers easily accessible through front and rear doors
  - Lower panels at A-, B-, and C-pillars
  - Door sill mouldings
  - Seat side and seat control panels
  - Connecting panels around the instrument panel
  - Side bolster covers, etc.
3. Interior Plastics – Luggage Compartment (Figure 8)
  - Tailgate trim and luggage compartment panels
  - Storage solutions and components around the load floor
  - Spare wheel well, inserts, and supporting structures

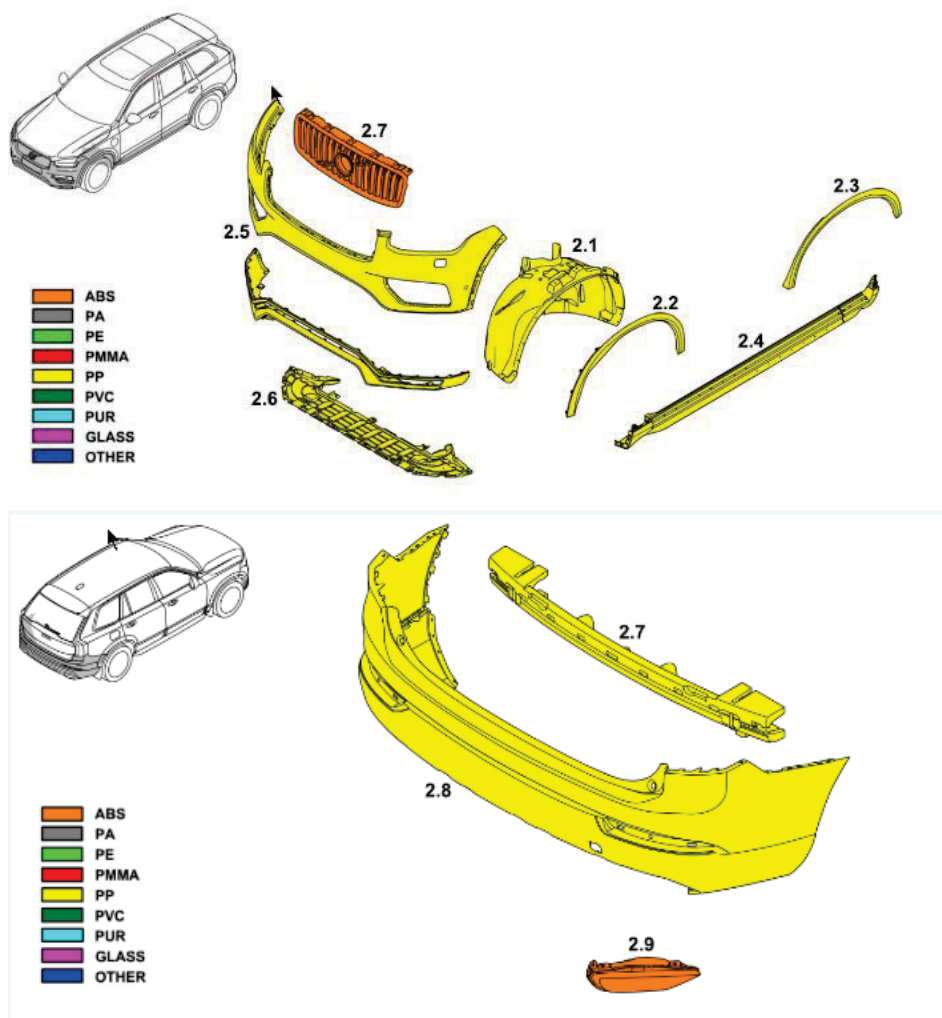


Figure 6. Components proposed for dismantling and recycling. Pictures IDIS.

- Bumpers (PP EPDM) (ex. 2.5,2.7,2.8)
- Sill mouldings (PP EPDM exterior) (ex. 2.4)
- Sill mouldings (ABS interior)
- Pillar panels (ABS interior)
- Air guides (bumper) (PP) (ex. 2.6)
- Trim moulding doors (PP EPDM)
- Wheel arch liners (PP talc) (ex. 2.1)
- Wheel arch extenders (PP EPDM) (ex. 2.2,2.3)
- Load floor supports (PC/ABS interior)

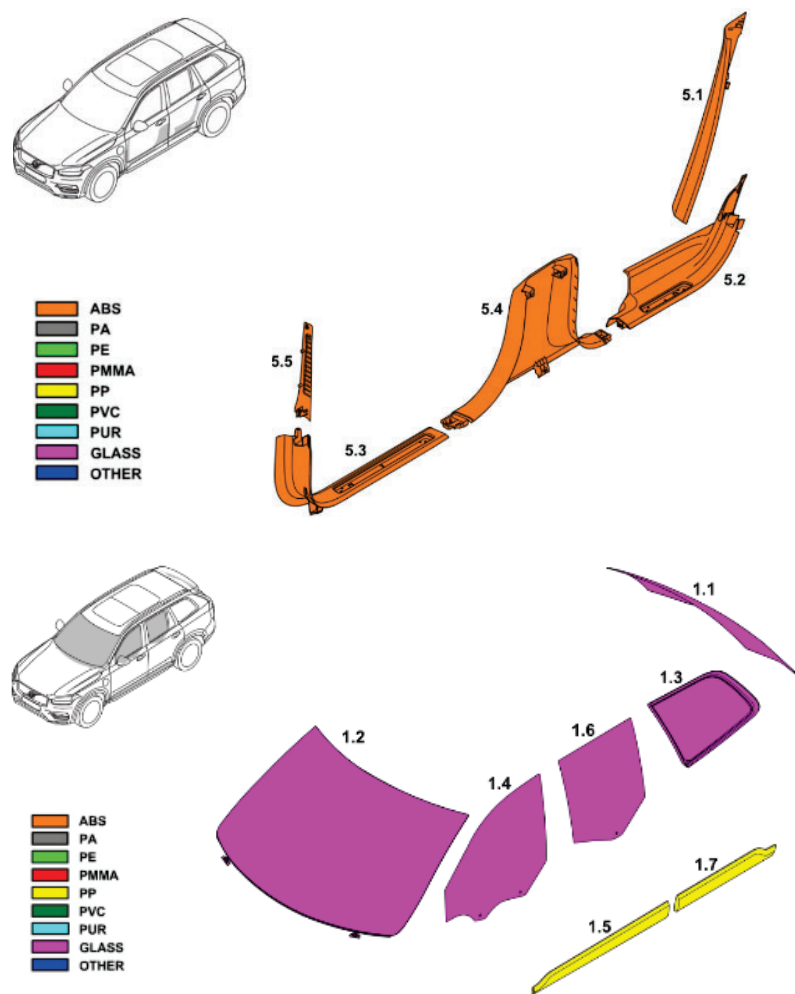


Figure 7. Components proposed for dismantling and recycling. Pictures IDIS.

- Bumpers (PP EPDM)
- Sill mouldings (PP EPDM exterior)
- Sill mouldings (ABS interior) (ex. 5.3,5.2)
- Pillar panels (ABS interior) (ex. 5.1,5.4,5.5)
- Air guides (bumper) (PP)
- Trim moulding doors (PP EPDM) (ex. 1.5,1.7)
- Wheel arch liners (PP talc)
- Wheel arch extenders (PP EPDM)
- Load floor supports (PC/ABS interior)

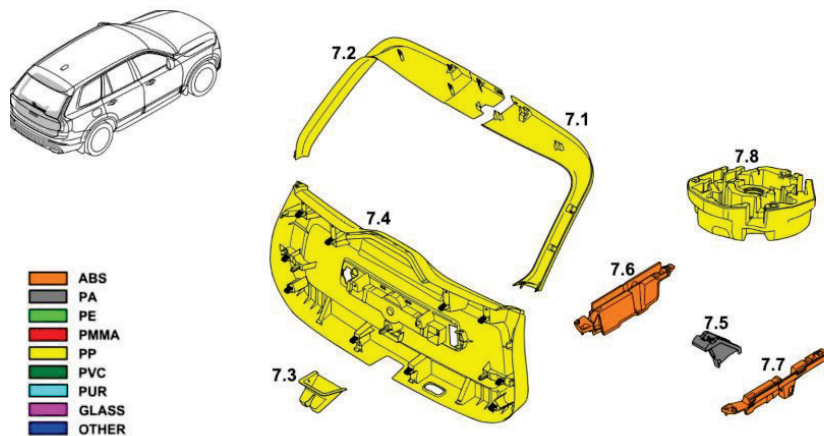


Figure 8. Components proposed for dismantling and recycling. Pictures IDIS.

- Bumpers (PP EPDM)
- Sill mouldings (PP EPDM exterior)
- Sill mouldings (ABS interior)
- Pillar panels (ABS interior)
- Air guides (bumper) (PP)
- Trim moulding doors (PP EPDM)
- Wheel arch liners (PP talc)
- Wheel arch extenders (PP EPDM)
- Load floor supports (PC/ABS interior) (ex.7.6,7.7)
- Rear bootlid inner panels (PP/PE+EPDM-MD15) (ex. 7.1,7.2,7.4)

See in Table 1, 2 and 3 the car models and components selected for the dismantling study.

Table 1. Components to dismantle for recycling from ~20y old Volvo models.

Component	Volvo V70	Volvo V50	Volvo V40
Bumpers	Front: 3,8-4,2 kg PP+EPDM Rear: 5,0-5,7 kg PP + EPDM	Front: 4,6 kg PP+EPDM Rear: 3,8-4,3 PP+EPDM	Front: 3,6 kg PP+EPDM Rear 4,2kg PP+EPDM
Sill mouldings Exterior	Total: 2 ×1,6 kg -2 ×1,9 kg PP + EPDM(PP)	Side: 2 × 1,5 kg PP+EPDM	Side 2 × 1,3 kg PP
Sill mouldings Interior	Total L+R: 0,9 kg ABS Boot: 0,5 kg- 0,9 kg ABS	Total L+R: 0,6 kg ABS Boot: 0,4 kg ABS	Total L+ R: 0,4 kg PP Boot: 0,4 -0,6 kg PP
Pillar panels Interior	Total A, B, C, D (V70): 2,8 kg ABS	Total A, B, C, D (V50): 2,2- 2,4 kg ABS	Total A, B, C, D (V40): 2,2- 2,4 kg PP
Air guides under bumpers	Lower: 1,9 kg PP+EPDM	Lower: 0,9 kg PP+EPDM	Lower: 1,0 kgPP
Wheel arch liners	Front: 2 x 1,0 kg PP Rear: 2x1,0 kg PP	Front: 2x1,1 kg PP Rear: 2x1,0 kg PP	Front: 2x0,5 kg PP Rear: 2x0,7 kg PP
Wheel arch extenders	Total front: (XC70): 0,4 kg PP+EPDM Total rear: (XC70): 1,1 kg PP+EPDM	-	-
Total	S80: 11,8 kg PP+EPDM, 0,9 kg ABS  V70(XC70C): 10,7(12,2) kg PP/EPDM 4,2 kg ABS	S70: 12,3 kg PP+EPDM, 4,2 kg PP, 3,2 kg ABS  V50: 12,8 kg PP+ EPDM, 4,2 kg PP, 3,4 kg ABS	S40: 7,8 kg PP+EPDM, 9 kg PP, 0kg ABS  V40: 7,8 kg PP+ EPDM, 9,4 kg PP

Table 2. Components to dismantle from ~20y old VW, Audi, Mercedes and Toyota.

Component	VW Passat B5	Audi A6	MB E	Toyota
Bumpers	Front: 5,5 kgPP+EPDM-TD10 Rear: 6,6 kg PP+EPDM-TD10	Front: 5,2 kg PP+EPDM Rear: 5,6 kg PP+EPDM	Front: 3,6 kg PP+EPDM Rear: 6,7 kg PC+PBT	Front: 3,5 kg PP+TD10 Rear: 4,4 kg PP-TD20
Sill mouldings exterior	-	Side: 2x2,9 kg PP+EPDM	-	Side 2x0,7 kg PP-TD20
Sill Mouldings interior	PP Boot: 0,8 kg PP	PP Boot: 0,6 kg ABS	Boot: 0,7 kg ABS	Boot: 1 kg PP/PE
Pillar panels interior	PP	Upper: ABS	B-pillar2x0,8 kg ABS A-pillar lower: 2x0,6 kg PP- TD 20	B-pillar: 2x 0,4 kg PP C-pillar: 2x 0,4 kg PP-TD20
Air guides under Bumper	PP	Lower: 2 kg PP-GF25	Lower: 1,6 kg PP-GF30	Low: 2x0,4kg PP/PE
Wheel arch liners	Front: 2x0,8 kg PP Rear: 2x1,95 kg PP	Front: 2x1,2 kg PP+EPDM Rear: 2x3,1 kg PP+EPDM	Rear: 1,5 kg PP+EPDM	Front: 2x0,6 kg EPDM
Wheel arch extenders	-	-	-	-

Table 3. Components to dismantle from ~10y old VW, Audi, Mercedes and Toyota.

Component	VW Passat	Audi A6	MB E	Toyota
<b>Bumpers</b>	Front: 4,1 kg PP+EPDM-TD10 Rear: 6,4 kg PP+EPDM-TD20	Front: 4,9 kg PP+EPDM+TD20 Rear: 3,8 kg PP+EPDM + TD20	Front: 3,0 kg PP+EPDM Rear: 5,6 kg PP+EPDM	Front: 4,1 kg PP+TD20 Rear: 3,8 kg PP-TD20
<b>Sill mouldings exterior</b>	-	Side: 2x1,4 kg PP+EPDM+TD30	Side: 2x3,5 kg PP+EPDM	Side 2x1,7 kg PP-TD20
<b>Sill Mouldings interior</b>	Interior: PP+PE Boot: PP+PE	PP/PE	Boot: 0,8 kg ABS	PP/PE
<b>Pillar panels interior</b>	PP+PE	Upper: B-pillar lower: PP/PE	-	PP/PE
<b>Air guides under Bumper</b>	PP	Lower: 1,9kg PP-GF30	Lower: 1,6 kg PP-GF30	Lowe: 2x1,5 kg PP-TD20
<b>Wheel arch liners</b>	Front: 2x0,9 kg PP+PE Rear: 2x0,6 kg PET	Front: 2x1,8 kg PP+EPDM	Front: 1,5 kg PP+EPDM	Front: 2x0,6 kg PE-HD
<b>Wheel arch extenders</b>	-	-	-	-

## Results

The measurements show that newer vehicles (approx. 10 years old) generally contain larger amounts of plastic, and that this plastic is easier to dismantle compared to older vehicles (approx. 20 years old).

Table 4. Dismantled plastic amounts and dismantling speed (takt).

Vehicle	Age (Year)	Total plastic (kg)	PP (kg)	Speed (g/min)
Volvo XC90	10	41,3	35,6	1203
Toyota Avensis	10	33,5	33,4	790
VW Passat B6	10	27,1	22,2	572
Volvo V50	20	24,7	18,6	651
Toyota Avensis	20	21,4	20,9	529
MB E W211	20	-	-	245

The PP grades were accounted to approx. 90% of the material in the category of 10 years old cars (91 kg / 102 kg). In the category of 20-year-old cars, PP represented approx. 85% (40 kg / 46 kg).

Figure 9-14 show the amounts of dismantled plastics from the different car models and the disassembly speed (Takt).

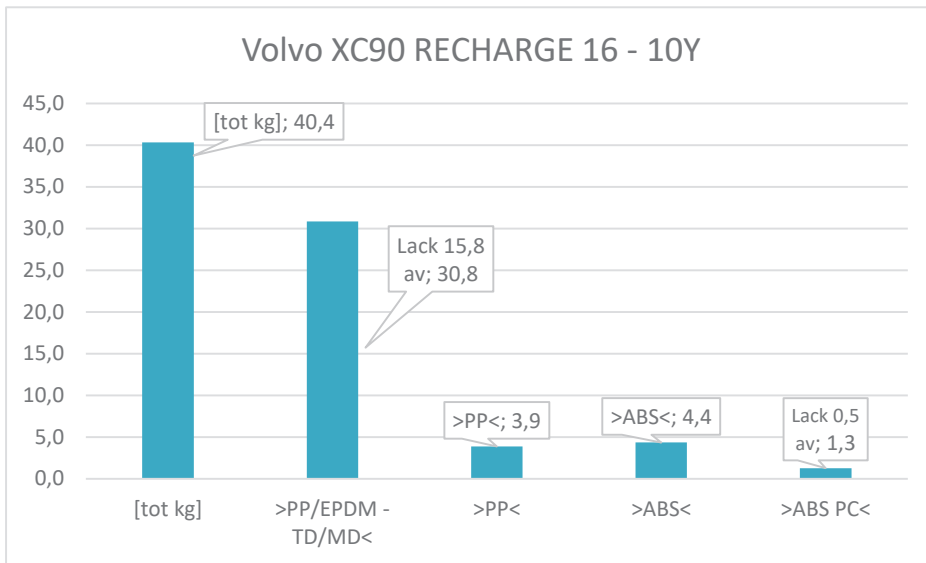


Figure 9. JB (Jönköping bildemontering), disassembly speed 1203 g/min.

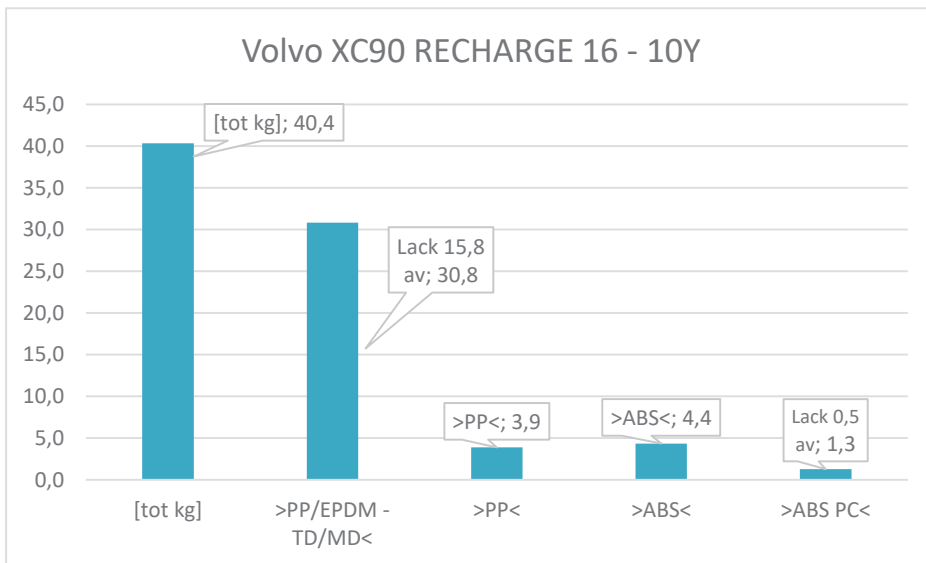


Figure 10. JB disassembly, 651 g/min.

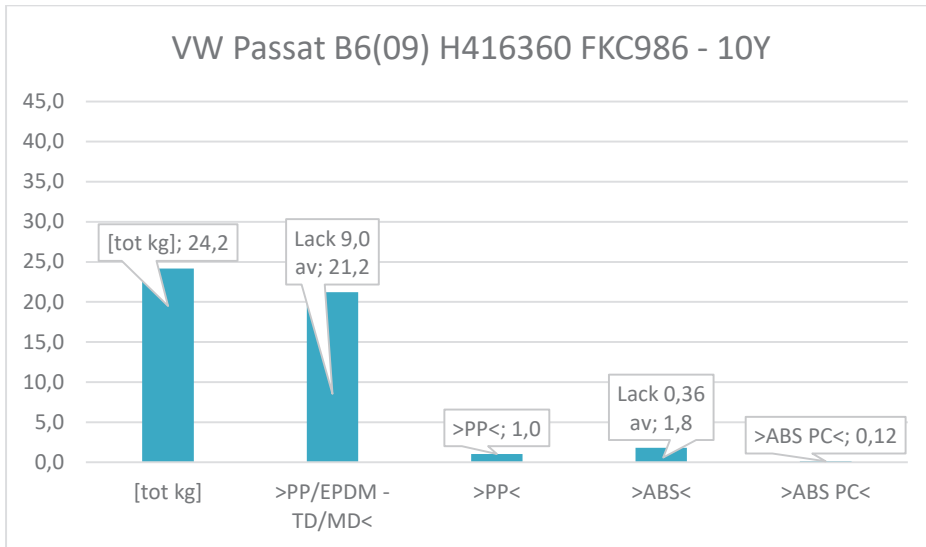


Figure 11. Walters, speed 572 g/min.

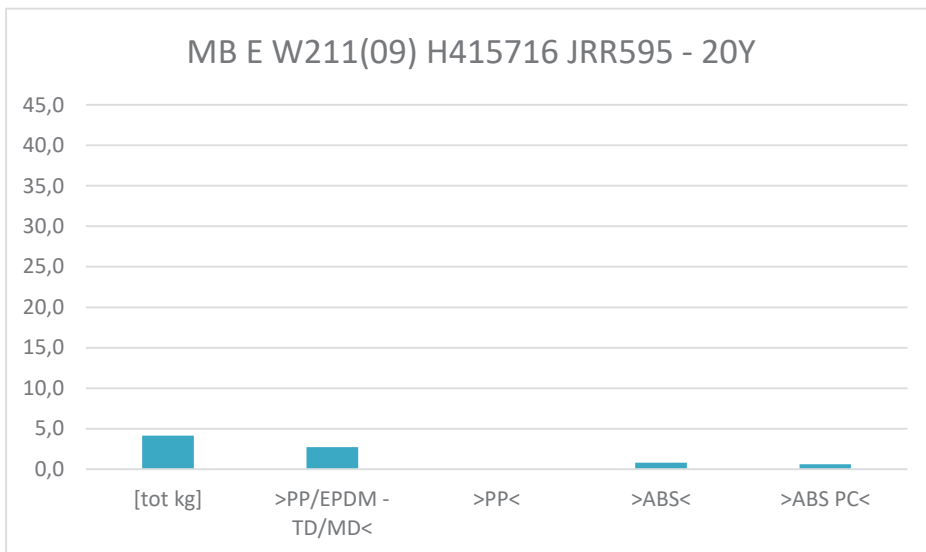


Figure 12: Walters, speed 529 g/min.

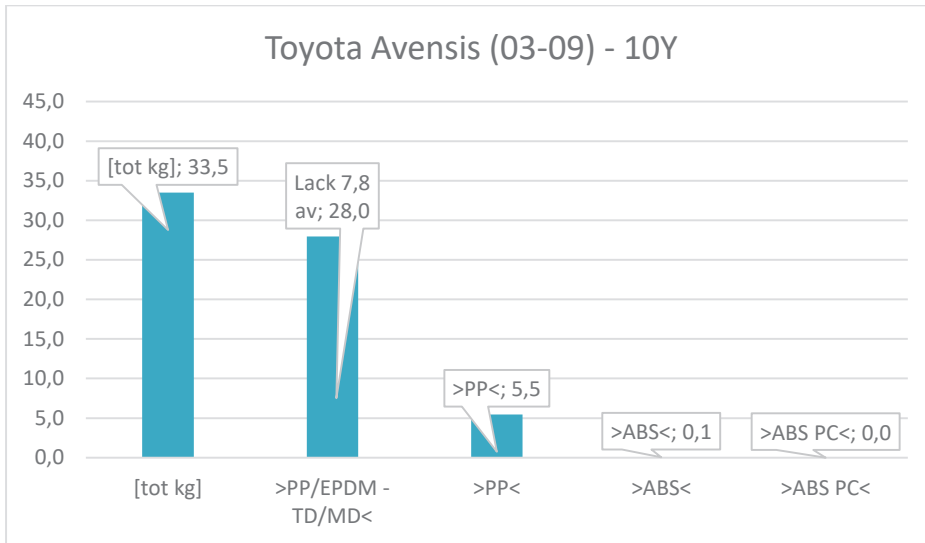


Figure 13. Eklunds, speed 790 g/min.

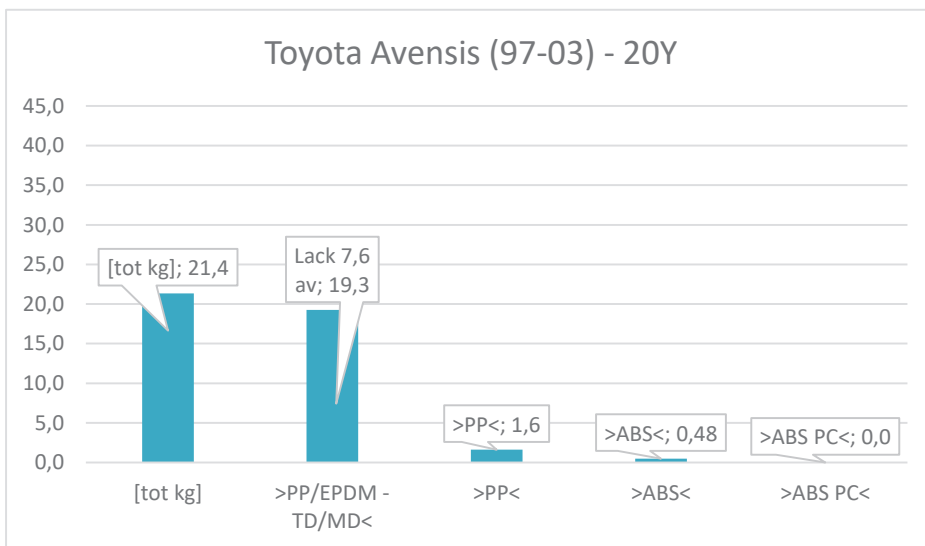


Figure 14. Eklunds, speed 529 g/min.

Volvo demonstrated slightly higher dismantlability performance in both age categories compared with the other manufacturers, followed by Toyota, Volkswagen and Mercedes-Benz. This appears to be linked to factors such as total plastic volume, component design, attachment solutions and overall construction principles.

Total dismantling time was measured in two steps: the dismantling time itself, followed by the time required to remove incompatible or unwanted materials. As shown in the table below, the removal of unwanted materials constitutes a substantial share of the total time. It is also noteworthy that painted plastics account for significant amounts of the dismantled material, primarily originating from exterior components such as front and rear bumpers.

Table 5. Share of painted plastic, time share for dismantling and cleaning respectively.

Vehicle	Age (Year)	Share of painted plastic (%)	Share of time dismantling (%)	Share of time cleaning (%)
Volvo XC90	10	51	36	64
Toyota Avensis	10	23	55	45
VW Passat B6	10	34	49	51
Volvo V50	20	41	50	50
Toyota Avensis	20	37	45	55
MB E W211	20	55	67	33

The condition and cleanliness of the vehicles had a clear impact on dismantling performance. For example, the MB E W211 was heavily soiled, and previous dismantling had already been started before the project test. The vehicle had been exposed to weather, components were missing, and loose plastic parts were scattered inside, making structured work, separation, sorting, and cleaning significantly more difficult. Consequently, the low TAKT value and plastic quantities for this vehicle were excluded from the aggregated analysis as they were not considered representative

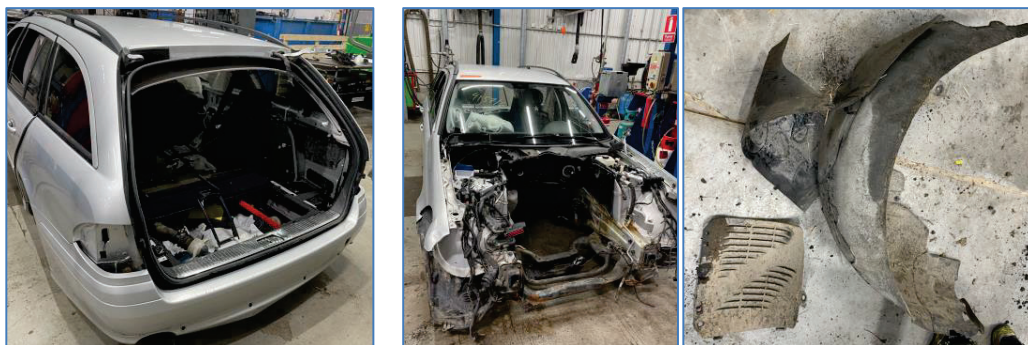


Figure 15. Difficult disassembly, clutter, contamination, and soiled plastic items.

An important insight is that variations in vehicle condition are common in dismantling operations, and that both cleanliness and the degree of intactness have a decisive influence on dismantling efficiency. Conducting a preliminary assessment of dismantling suitability and vehicle condition before starting physical work may therefore be advantageous.

Although volumes differ between models and brands, general distinctions can be observed between older (Y20) and newer (Y10) vehicle generations. Newer vehicles typically contain larger overall quantities of plastic, often in the form of larger and more integrated exterior plastic systems.



Figure 16. Example of larger painted exterior plastic part on a modern vehicles.

In older vehicles, interior components were more commonly produced from ABS, whereas today PP-based materials dominate. In the project's component selection, ABS was rare among easily accessible interior components. An exception is the Volvo XC90, but even there the volumes of ABS were low. It may be that the use of ABS today is less driven by technical properties and more by tactile and aesthetic preferences affecting perceived quality.

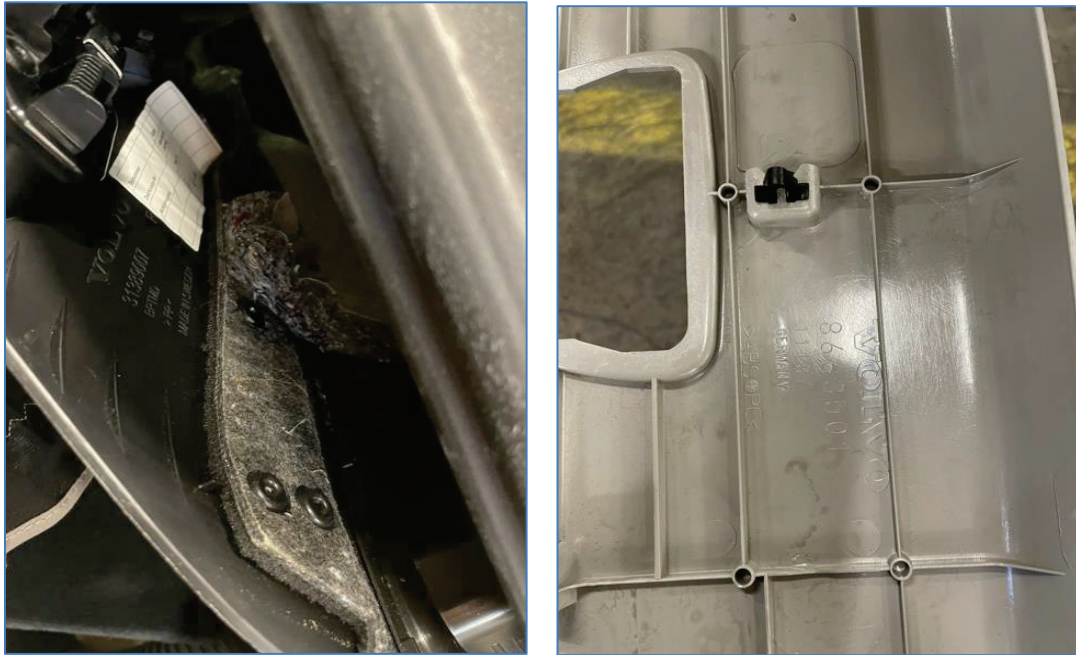


Figure 17. Example of a composite PP article as well as ABS/PC plastic components in luggage compartment.

A broader structural trend in modern vehicles is the integration of an increasing number of digital and sensor-based systems. Examples include advanced driver assistance systems and safety features using radar, lidar, cameras, and other sensors. This results in additional electronic components embedded into plastic parts, especially front and rear bumper systems.

While such features benefit consumers, they increase the complexity of component designs. From a material-recycling standpoint, it would be desirable to integrate stronger design-for-recycling principles to ensure quick, clean separation of electronic and foreign materials from recyclable plastic components.

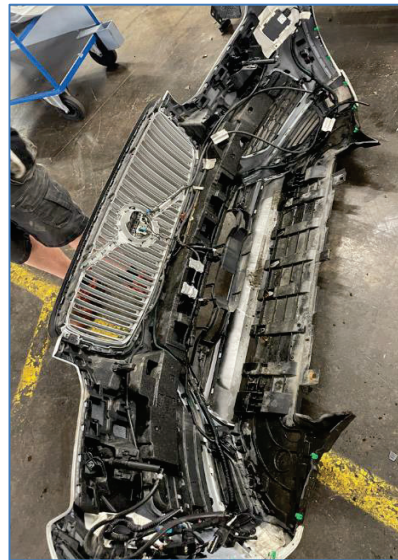


Figure 18. Bumper cover removed.

Another trend in modern cars is the growing use of compression-moulded polyester textile due to low weight, cost savings and comfort. It is used in interior parts and also in wheel arch liners inside the wheel housings. During dismantling, these fiber materials in wheel housing are heavily soiled and the material is not feasible to recycle with mechanically. In contrast, PP-based solutions for wheel arch liners have significantly better performance in terms of circular mechanical material recycling.



Figure 19. Inner fenders made of PET and PP-based material respectively.

### **Proposed Pick List for Material from a “Typical Vehicle”**

An initial proposed picking list has been developed based on practical dismantling experience and information from IDIS. The focus is on dismantling plastic components made of recyclable materials with high dismantling efficiency, i.e. components that generate a high material yield per unit of time during dismantling. PP-based materials dominate the selection, and from an efficiency perspective, large exterior components at the front and rear of the vehicle are of particular interest. A reasonably forward-looking target for dismantling efficiency (TAKT) for the components included in the visual picking list below is  $TAKT > 1000 \text{ g/min}$ . This indicative TAKT level can be used as a plausibility benchmark when assessing and evaluating the efficiency of manual dismantling and thereby support decision-making regarding the inclusion or exclusion of plastic components for dismantling and material recycling.

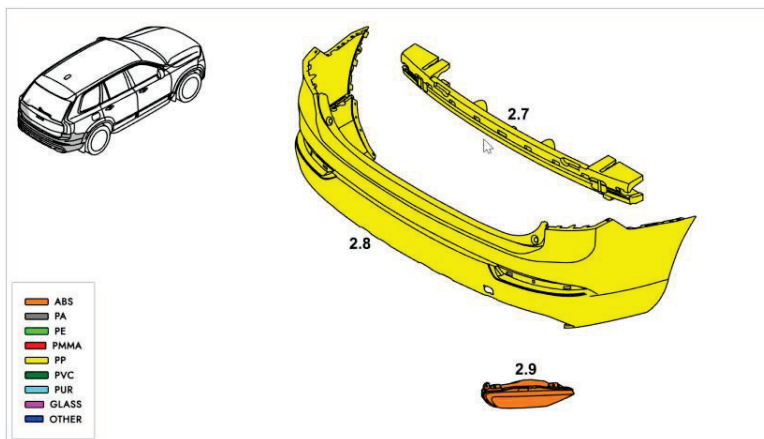
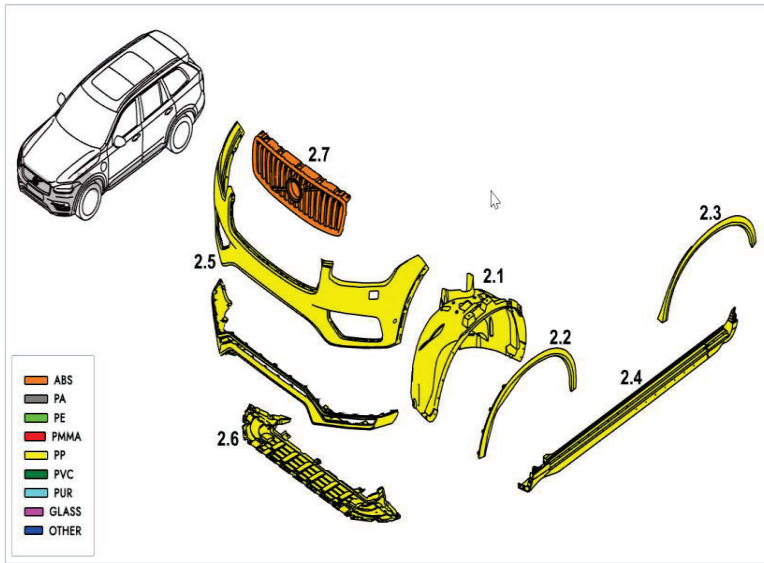


Figure 20. IDIS visual picklist Volvo XC90 II (SPA1) MY2015

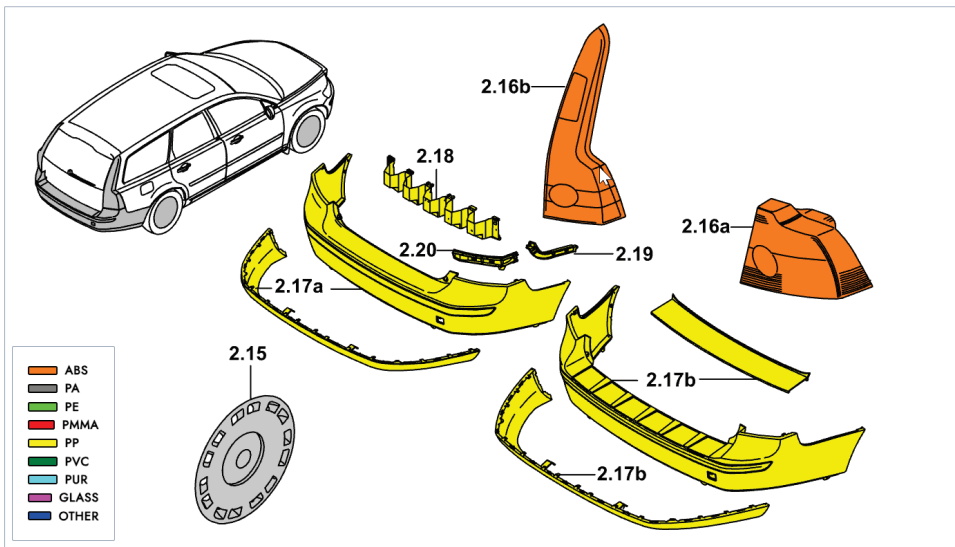
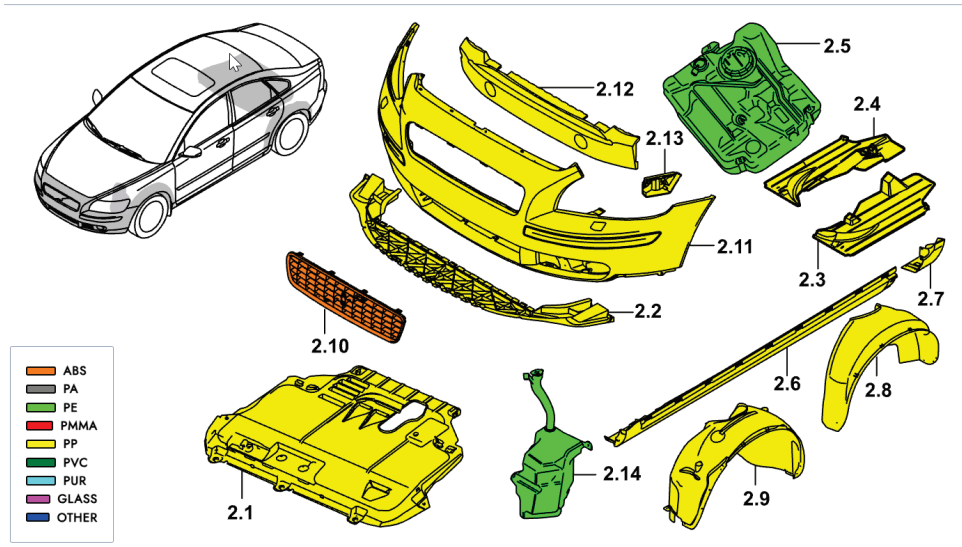


Figure 21. IDIS visual picklist Volvo V50 (P1) MY2004-2012

More picklists for all the car models in the study can be found in the report of work package 2<sup>9</sup>

<sup>9</sup> Dismantling of plastics from end-of-life vehicles

## **Areas for improvement**

The management of the plastics need to be very well organized and efficient to be practically and economically feasible. The work process needs are:

### 1. Standardization of Form

- **Transportability:** Volume reduction prior to transport can be crucial for cost efficiency. Increasing density through compaction or shredding should be considered (\* see note below).
- **Packaging:** Use adapted and clearly labelled packaging (big bags, pallets, containers) indicating material type, quality code, cleanliness level and traceability.
- **Material fractions:** Standardized fractions are needed to define acceptable blends and to streamline sorting.

### 2. Standardization of Process

- **Collection containers:** Clear labelling and colour-coding at the dismantling line support correct sorting.
- **Internal logistics:** Containers should be movable, simple to handle and adaptable (e.g., cages, drums, big bags).
- **Washability:** Containers should be compatible with coarse cleaning in wash systems with minimal disruption to workflow.

### 3. Business Process and Leadership

- **Clear leadership:** Product owners should take an active governing role, setting requirements and driving progress in circular plastic recycling.
- **Collaborative value chain:** Increased cooperation between dismantlers, recyclers, compounders and plastic manufacturers is essential for establishing a well-functioning value chain.
- **Standardization and control:** Shared standards for classification, analysis, quality control and regulation of material flows are needed to build trust and ensure long-term stability.

\* Note on Volume Reduction, Recyclers highlight potential risks associated with volume reduction before the recycling process begins. There is a possibility that material mixing may occur during compaction or shredding at the dismantling site. This concern is understandable, as recyclers require full control over process and material composition, especially given the strong influence of contamination and mixed materials on the quality of the final product. With strengthened collaboration, a quality-assured workflow, and appropriate testing and categorization methods, early-stage volume reduction may become viable. Without volume reduction, materials are bulky, and the low density significantly impacts transport and storage cost.

### *Conclusions and deliverables from WP2*

The results from this work package demonstrate that dismantling of plastic components is a critical enabler for establishing circular plastic recycling within the automotive industry. The potential is considerable, and many components can already be dismantled efficiently under the right conditions. At the same time, dismantling outcomes are strongly influenced by vehicle design, condition and age, highlighting the need for both design improvements and process development.

To increase the utilisation of recovered material and support a viable circular plastic system, several conditions must be met:

- **Efficient integration of material recycling into dismantling operations**, ensuring standardized, traceable and well-sorted high-quality material flows that meet the requirements of subsequent recycling and compounding processes.
- **Clear business conditions and governance**, including harmonized requirements from product owners and practical, well-adapted support functions for material testing, classification, quality assurance and documentation. Predictable and uniform requirements across the value chain are essential for building confidence and establishing stable material flows.
- **Design for circularity in new vehicle development**, where components are designed from beginning to enable straightforward dismantling, efficient separation of materials, and high-quality mechanical recycling. Future plastic components must be better optimized for manual dismantling, both in terms of attachment solutions and material composition. Stronger targets and requirements are needed, with increased focus on circular materials and design solutions that enable fast, clean and low-effort material separation. Dismantling and separation time should be regarded with the same importance as assembly time in manufacturing, as efficient dismantling is fundamental to making circular material recovery economically viable.

A clearly mandated product owner with authority to set requirements across the value chain is a key success factor for building a high-volume and commercially viable circular plastic recycling system. A relevant benchmark is the well-established Swedish reuse model for automotive repair and insurance cases, where reused components are routinely installed instead of new ones. This model succeeds because it is supported by strong economic incentives, clear mandates and requirements that guide the entire value chain. The same type of coordinated governance will be necessary to accelerate the transition to circular plastics in the automotive sector.

## Preparation and characterization of ELV recyclates (WP 3)

### *Performance*

Plastic parts dismantled in Work Package 2 from Volvo, Toyota and Polestar vehicles were delivered to RISE in Mölndal. The components originated from cars approximately 20, 10 and 5 years old. Upon arrival, the materials from the ELV vehicles were sorted into the following fractions: PP-based plastics (including PP with EPDM and talc filler), glass-fiber-reinforced (GF) PP, painted PP, EPP (expanded polypropylene), ABS, and PC/ABS (see some examples of components in Figure x-y). Soiled parts were cleaned using high-pressure air and, when necessary, water; however, the most heavily soiled parts were excluded. Certain components were laminated with foam, which was removed as far as possible before further processing.



Figure 22. ABS from 20-year-old V70 and V50.



Figure 23. PP plastic with EPDM and mineral filler, from 20-year-old V70 and V50.

Bla



Figure 24. PP with glass fibre, from 10-year-old XC90.



Figure 25. Painted PP with EPDM, from 10-year-old XC90.

After cleaning and sorting, the plastic parts were shredded and dried in a desiccant dryer, after which antioxidants and process aids supplied by Polykemi were mixed into the materials. The materials were compounded using a Coperion ZSK 26 twin-screw extruder, melt-filtrated (except for GF PP and EPP materials), cooled and pelletized (see compounding Figure 26 and blends compounded Figure 6).



Figure 26. Compounding in a Coperion ZSK 26 twin-screw extruder equipped with a Gneuss melt-filter system.

Table 6. ELV plastic blends compounded.

Age (Y)	Model	Material	Comments, melt-filter size etc
20	Volvo V70+V50	PC/ABS	70 µm filter
20	Volvo V70+V50	ABS	70 µm filter, smell
20	Volvo V70+V50	PP+ EPDM+MD	120 µm filter
10	Volvo XC90	ABS	smell
10	Volvo XC90	PP+ EPDM+MD	120 µm filter
10	Volvo XC90	PP+ GF+TPE	
10	Volvo XC90	PP+ EPDM+MD	Painted white, strong smell, 70 µm filter
10	Volvo V60	ABS	70 µm filter smell
10	Volvo V60	PP TD	120 µm filter
10	Volvo V60	PP GF	
10	Toyota Avensis	PP +E/P+T	120 µm filter
10	Toyota Avensis	EPP	
5	Polestar	ABS	
5	Polester	PP+EPDM+TD	70 µm filter
5	Polestar	PP+GF	

The materials generated odour when heated up in the compounder, especially the painted bumper PP material of the Volvo XC90. The ABS and PC/ABS generated more odour than the PP materials in general. The painted bumper material had a strong odour.

The material characterization was performed by RISE and RondoPlast.

Rise performed:

- FTIR-analysis on films in transmission mode to identify the polymers, possibly signs of oxidation and contaminants in the ELV recyclate compounds.
- MFR - Melt-flow-rate measurements
- TGA - Thermo Gravimetric Analysis to determine polymer and inorganic content.
- DSC – Differential Scanning Calorimetry to determine melting temperature and enthalpy of the crystalline polymers (PP based plastics).
- OIT – Oxidative Induction Time was measure for the PP based plastics isothermally at 200°C in oxygen atmosphere. The time to oxidation (OIT) was measured. OIT gives information about the level of active antioxidant in the plastic.

RondoPlast produced injection-molded test specimens and performed mechanical testing, impact testing, odour and emission assessment:

- Notched Charpy, measure of impact property.
- Tensile strength, measure of the maximum pulling stress a material can withstand before breaking or deforming.
- Flexural modulus, measure the stiffness of a material.
- Odor PV3900, evaluation of odor.
- VDA277: Head space – analysis (5 hrs @ 120 °C), measures amount of volatile organic compounds.

### ***Results***

The DSC analyses showed that the PP based materials had a large melt peak (melt-enthalpy) corresponding to PP + PP-PE copolymer. All the analysed compounds contained a small melt peak corresponding to polyethylene, except the Volvo V90 blend of PP, GF and TPE. The polyethylene most probably originates from PP-copolymer material in the blends. Antioxidants had been added to prevent thermal oxidative degradation when processing the blends. The added antioxidants influence on the measured oxidative induction time (OIT). OIT > 40 min means that the material is well stabilised. The expanded PP (EPP) from the Toyota was difficult to feed into the compounder and the process time was long, hence much of the antioxidants was consumed in the compounder. The painted bumper material had also a long process time due to the melt-filtration of paint, thus, antioxidant was consumed resulting in low measures of OIT. The deviation between test samples were quite large for the painted bumper material of Volvo V90.

Table 7. ELV plastic blends, melt peaks and OIT

Age (Y)	Model	Material	Melting points (°C)	OIT (minutes)
20	Volvo V70 + V50	PP + EPDM + T	Melt Peak PE = 127-132°C (small)	26
			Melt Peak PP = 165-168°C	26
				26
10	Volvo V90	PP + EPDM + MD	Melt Peak PE = 127°C (small)	41
			Melt Peak PP = 165-166°C	53
				57
10	Volvo V90	PP + GF + TPE	Melt Peak PP = 164, 165, 166°C	37
				45
				47
10	Volvo V90	PP + EPDM + white paint	Melt Peak PE = 126-127°C (small)	7
			Melt Peak PP = 164-166°C	9
				27
10	Volvo V60	PP + TD	Melt Peak PE = 128-129°C (small)	56
			Melt Peak PP = 165-168°C (large)	>60
				>60
10	Volvo V60	PP + GF	Melt Peak PE = 132°C (large)	>60
			Melt Peak PP = 166°C (small)	>60
				>60
10	Toyota Avensis	PP + E/P + T	Melt Peak PE = 126-127°C (very small)	8
			Melt Peak PP = 166°C	14
				14
10	Toyota Avensis	EPP	Peak PE = 120-127°C (small)	2
			Peak PP = 165-167°C	6
				10
5	Polestar	PP + EPDM + TD	Melt Peak PE = 125-130°C	47
			Melt Peak PP = 164-166°C	57
				>60
5	Polestar	PP + GF	Melt Peak PE = 132°C (very small)	41
			Melt Peak PP = 167-168°C	56
				>60

For the PC/ABS and ABS materials; the flexural modulus was a bit lower than expected. The materials generated also quite high odor values and volatile emissions which indicates some degradation. It was also indicated in the FTIR spectrum that the ABS from 20 years old V70 + V50 was oxidised. The butadiene part of the ABS is sensitive to oxidation. However, looking at the mechanical properties of the PC/ABS and ABS materials, the properties are quite ok and can probably be used as part of a new material recipe for automotive applications.

Table 8. Properties of PC/ABS and ABS recyclate compounds.

Age	Model	Material	Ash content	Density	MFR	Charpy @23°C	Charpy @-30°C	Tensile strength	Flexural modulus	Odor	VDA
20	V70+V50	PC/ABS	3	1,104		13	5	75	2220	3,4±0,9	33±2
20	V70+V50	ABS	1	1,1056	3	8	5	75	2340	3,6±1,0	45±2
10	XC90	ABS	0	1,1032		15	7	66	2150	2,8±0,5	30±1
10	V60	ABS	0	1,1035	2	11	6	68	2280	4,0±0,3	37±2
Y			Wt %	g/ml	g/10 min	KJ/m <sup>2</sup>	KJ/m <sup>2</sup>	MPa	MPa		µg C/g

For talc filled and elastomer modified PP, the elastic part is suspected to slightly affected to give lower impact values than expected. MFR is somewhat lower compared to virgin material. However, the mechanical properties for the evaluated PP compounds from 5, 10 and 20 year old cars show that they are useful raw materials for new applications in the automotive industry. They should preferably be used as a part of the new material recipe. The compounds generated quite high odor values, especially the painted bumper material. FTIR analysis performed on the PP based materials did not indicate any oxidation.

Table 9. Properties of PP based recyclate compounds

Age	Model	Material	Ash content	Density	MFR	Charpy @23°C	Charpy @-30°C	Tensile strength	Flexural modulus	Odor	VDA
20	V70+V50	PP+EPDM+T	14	0,998	12	8	3	37	1930	4,0±0,4	11
10	XC90	PP+EPDM+MD	15	1,006	10	36	3	31	1480	4,4±0,5	6
10	XC90	PP+EPDM+T Painted	21	1,051	12	25	5	23	1340	4,3±0,8	1
10	V60	PP+TD	16	1,1022	11	12	3	36	1810	3,2±0,7	2
10	Toyota Avensis	PP+E/P+T	8	0,965	15	8	3	34	1430	3,7±0,6	9
	Polestar	PP+EPDM+TD	17	1,029	12	25	3	30	1520	3,9±0,7	1
Y			Wt %	g/ml	g/10 min	KJ/m <sup>2</sup>	KJ/m <sup>2</sup>	MPa	MPa		µg C/g

When looking at the mechanical properties For PP GF, the tensile properties reveal possible shortening of glass fibers.

Table 10. Properties of PP glass-fiber reinforced recyclate compounds.

Age	Model	Material	Ash content	Density	MFR	Charpy @23°C	Charpy @-30°C	Tensile strength	Flexural modulus	Odor	VDA
10	XC90	PP+GF+TPE	30	1,169	16	6	4	75	5090	Not tested	6
10	V60	PP+GF	28	1,1099	13	8	4	63	3840	2,7±0,8	6
5	Polestar	PP+GF	25	1,1093	14	5	3	85	4620	2,8±0,7	2
Y			Wt %	g/ml	g/10 min	KJ/m <sup>2</sup>	KJ/m <sup>2</sup>	MPa	MPa		µg C/g

## Conclusions

- The mechanical properties for the evaluated materials show that they are useful raw materials for new applications in the automotive industry. They should preferably be used as a part of the new material recipe
- Long time properties of the materials need to be evaluated.
- Looking at this study, it is suspected that the following draw backs can be valid for different kinds of materials
  - For styrenics, the ABS or PC/ABS qualities investigated, the emission values according to VDA 277 are at a level to suspect some material degradation
  - For PP GF, the tensile properties reveal possible shortening of glass fibers
  - For talc filled and elastomer modified PP, the elastic part is suspected to be slightly affected to give lower impact values than expected
  - Painted parts generate high odor values

## **Re-design for circularity (WP 4)**

In a closed-loop system, the benefits are twofold; disposal costs are reduced, as materials that would otherwise be treated as waste are recovered, and the carbon footprint decreases due to the higher share of recycled content.

### ***Performance***

Work Package 4 was carried out by Mocom, KB Components, Artifex Systems, Plasman and RISE, with Volvo Cars and Stena Recycling participating as discussion partners.

Three components were selected for redesign studies, focusing on their recyclability and on how their design could be improved to support closed-loop recycling:

- **Rear spoiler**
- **Door panel**
- **B-pillar**

These studies assessed both the current recyclability of the components and the design modifications needed to improve material separation, reduce contamination risks and enable higher-quality mechanical recycling in future vehicle applications.

## **Recycling processes at Mocom**

Mocom operates a broad range of industrial recycling processes that together enable high-quality recovery and upgrading of post-consumer (PCR) and post-industrial (PIR) automotive plastics. The available technologies include:

### ***In-house developed processes***

- Composite separation – separation of multi-material structures to isolate polymer fractions.
- Paint-removal process – proprietary technology for removing coatings, enabling higher-quality recyclates.

### ***Shredding technologies***

- Size reduction of parts to defined flake dimensions suitable for downstream separation steps.

### ***Separation technologies***

- Density separation – wet or dry processes that sort plastics based on density differences.
- Colour sorting – optical sorting for achieving more homogeneous material streams.

- Demetalization – removal of metallic contaminants from shredded fractions.
- Electrostatic separation – separation of polymers based on electrical charge behaviour.

### ***Repelletization and compounding***

Mocom produces application-ready recyclate compounds using:

- Melt filtration (60, 80, 120  $\mu\text{m}$ ) to remove fine contaminants.
- Formulation according to customer-specific requirement profiles.
- Vacuum degassing to remove volatiles and improve material quality.

### ***Material portfolio***

Mocom processes both PCR and PIR plastics from the automotive sector. The primary polymers handled include: PP, PP+EPDM, ABS, PC, PC+ABS and PA.

These materials constitute the dominant polymer types in current and future automotive applications and represent key candidates for closed-loop mechanical recycling.

## **Components and composition of materials**

### **Rear spoiler**

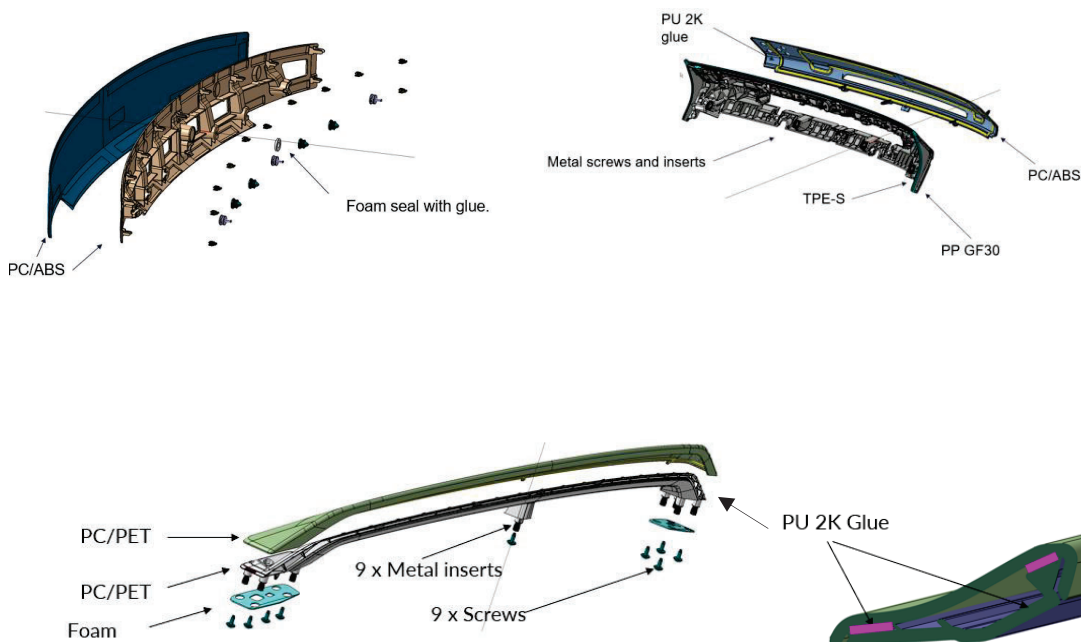


Figure 27. Rear spoiler composition.

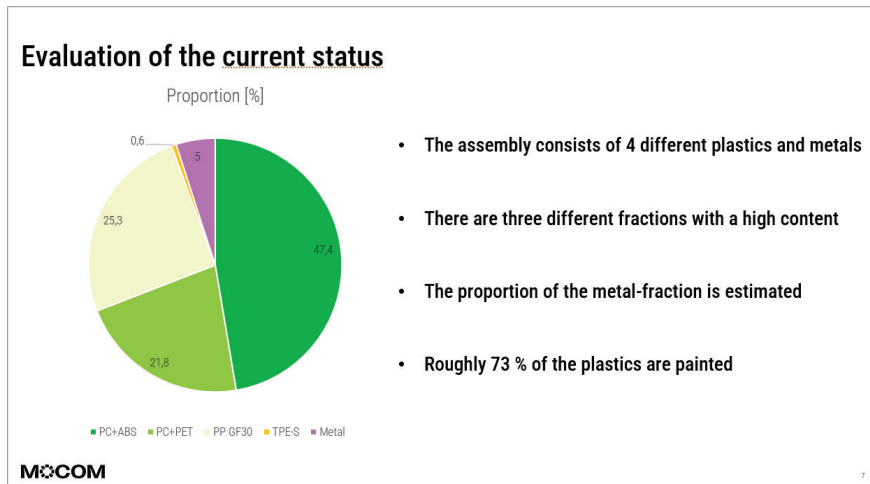


Figure 28. Current status rear spoiler.

### Rear spoiler analysis

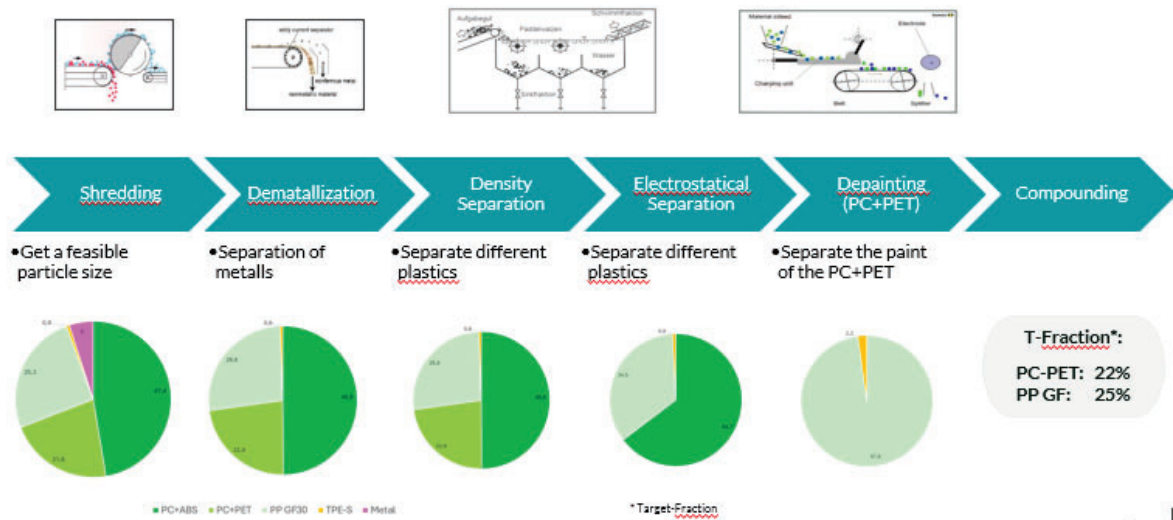


Figure 29. Analysis rear spoiler.

## **Recycling feasibility and design conclusions for the rear spoiler**

The recycling of the rear spoiler (composed of PP-GF30 and PC+PET) is technically feasible; however, it is not economically viable. The component contains a high proportion of material that becomes waste (>50%), and the recycling process is comparatively long and resource-intensive. While several design-for-recycling aspects are already partly considered, additional improvements are required. The most significant barriers to efficient recycling are the painted PC+ABS surfaces and the adhesive-based attachment methods, both of which hinder clean material separation and add substantial processing effort.

### **Conclusions – Rear spoiler**

#### ***Material selection***

- Use PP as the preferred base material wherever possible.
- Add mineral fillers when moderate stiffness is required.
- Use glass fibre reinforcement when higher stiffness is needed.
- Avoid combining PPTD30 and PPGF30 within the same component, as their similar densities make separation difficult.
- Ensure a minimum density difference of 0.04 when different materials must be used in the same part, to enable effective separation.
- Select mutually compatible materials, using established compatibility lists to support closed-loop recycling.
- If painting is necessary, avoid polymers from which paint cannot be removed (e.g., PC/ABS).

#### ***Process***

- If welding is used, apply welding only between identical or fully compatible materials to facilitate downstream separation.

#### ***Fixation and attachment***

- Prefer welding and metal-based fastening solutions, as these allow quicker and cleaner dismantling.
- Avoid POM or PA clips, since they introduce incompatible materials that reduce recycle quality and complicate process efficiency.

## Door panel

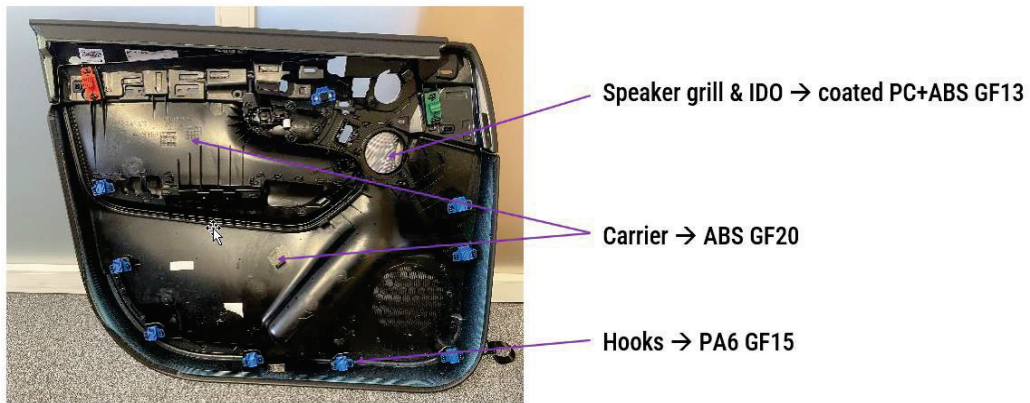
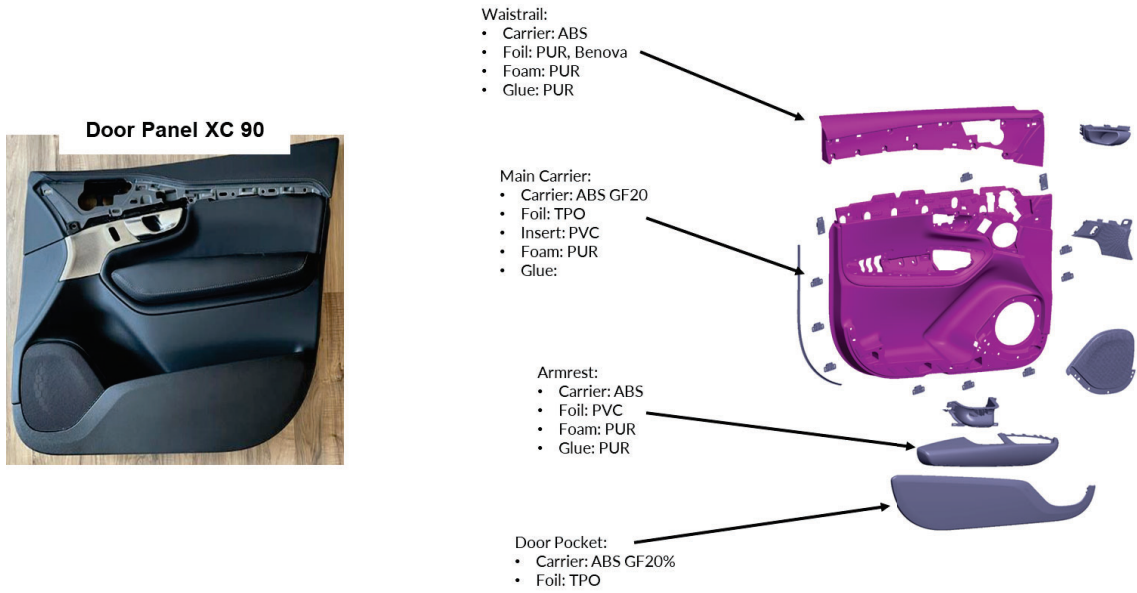


Figure 30. Door panel composition.

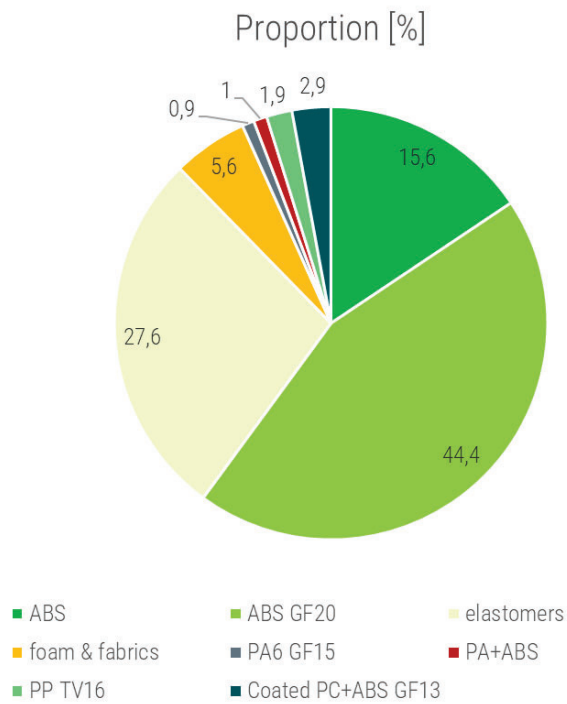


Figure 31. Current status door panel.

### Door panel analysis

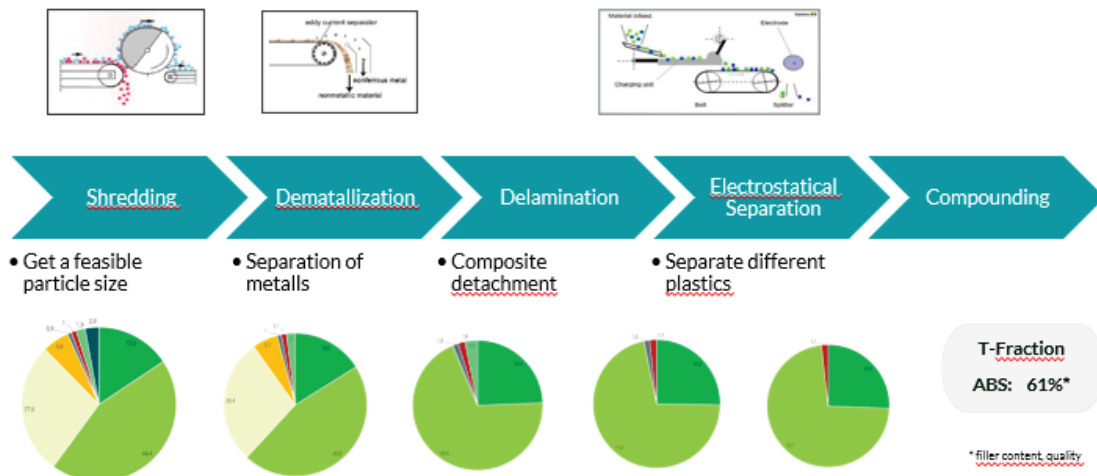


Figure 32. Analysis door panel.

## **Recycling feasibility and design conclusions for the door panel**

The recycling of the selected door panels is not currently feasible for producing high-quality recyclate. Material losses are substantial due to the large number of different polymers present, and contamination is significant, largely driven by the component's connection methods and multi-material construction. As a result, the proportion of recoverable target material is low, making the process economically unattractive. Overall, the design requires considerable improvement to meet future *Design for Recycling* (DfR) expectations.

## **Conclusions – Door panel**

### ***Material selection***

- Priority 1: Mono-material approach  
Use PP-based systems wherever possible, including PP with mineral filler (MD) or glass fibre (GF), as well as TPO and PP-based foam and adhesive systems.
- Priority 2: Avoid incompatible material combinations  
Reduce mixing of polymers that complicate separation or degrade recyclate quality.
- Priority 3: Use materials with distinct separability characteristics  
Select materials that differ clearly in density, tribo-electric behaviour or colour to facilitate downstream sorting.
- General recommendation:  
Integrate clips and hooks directly in the injection-moulding process to eliminate the need for incompatible attachment components. When external clips are necessary, metal clips are preferred over POM, which introduces an incompatible polymer stream.

### ***Process considerations***

- Avoid lamination unless the solution is mono-material; laminates covering large surface areas significantly reduce recyclability.
- Avoid gluing and incompatible welding techniques, as these create composite structures that are difficult to separate without destroying material quality.

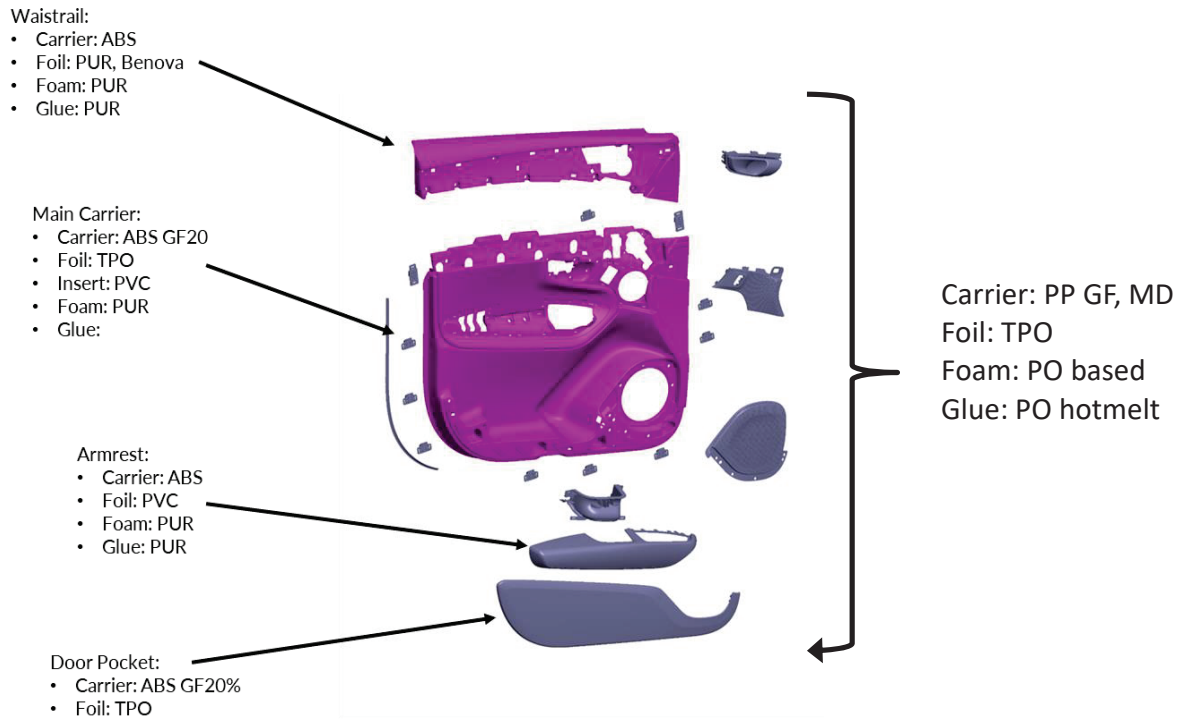


Figure 33. Redesign proposal door panel.

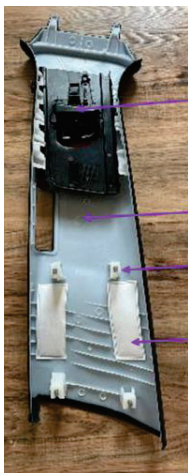
## B-Pillar



Hanger → PA+ABS

Belt guide → ABS

Fabric → PET



Adjuster → PP+EPDM TV15

B-Pillar → PC+ABS

Clips → Metal

Pads → Cell Foam

Figure 34. B-pillar composition.

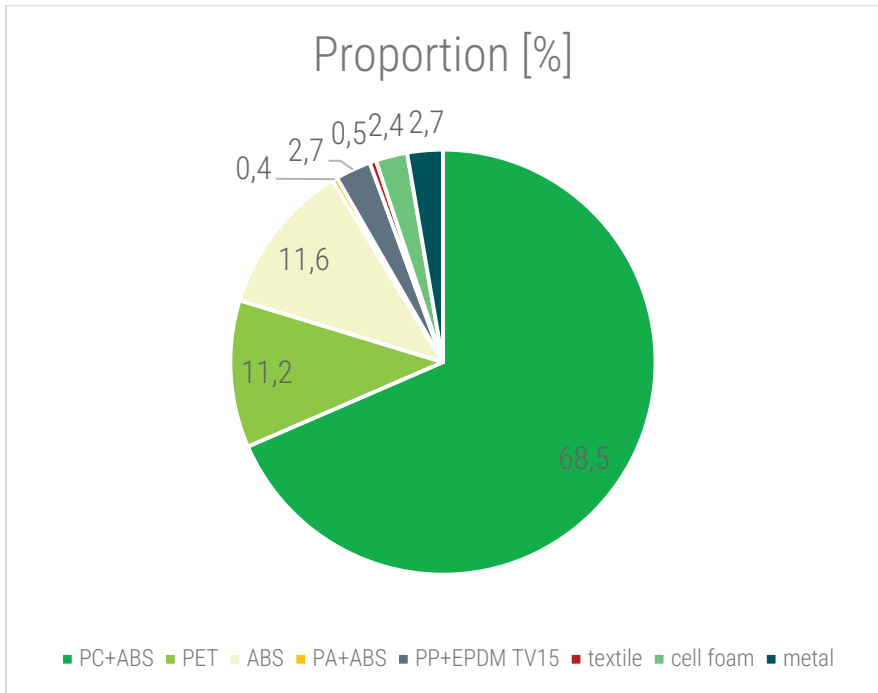


Figure 35. Current status B-pillar.

The assembly consists of 8 different materials. Based on the proportion, PC+ABS will be the target fraction on which the treatment process is based.

### B-Pillar analysis

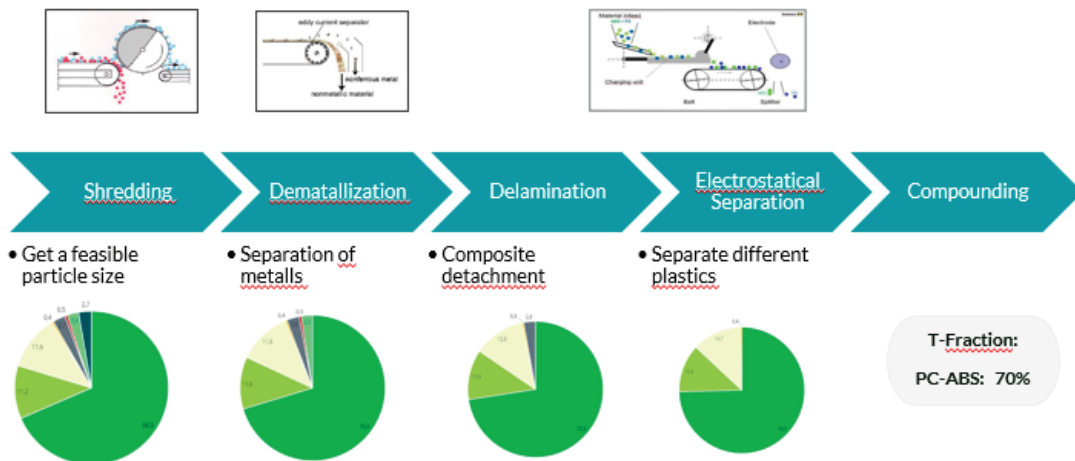


Figure 36. Analysis B-pillar.

## **Recycling feasibility and design conclusions for the B-pillar**

The recycling of the B-pillar casings is technically feasible, and several design-for-recycling aspects are already partly addressed. The connection methods used are generally favourable, and the polymeric materials bonded together are, in this case, compatible with one another. However, there are still design elements that require further improvement to optimise the component for closed-loop recycling.

## **Conclusions – B-pillar**

### ***Material selection***

- Prioritise mono-material solutions. A potential improvement would be to harmonise materials by converting the adjuster from PP to ABS or PC/ABS, thereby enabling more homogeneous material streams.
- Avoid incompatible material combinations. For example, redesigning the hanger (currently PA/ABS) using a compatible polymer would reduce contamination and simplify separation.
- Eliminate textile fabrics in future B-pillar designs to prevent PET contamination in the final recyclate. Removal of fabrics is labour-intensive and results in mixed fractions that reduce both material quality and economic viability.

## **Recycling system and business model (WP 5)**

### **Performance**

Three recycling system scenarios were developed and evaluated for Swedish ELV plastic recycling: centralized (Scenario A), distributed regional (Scenario B), and export to Germany (Scenario C). Each scenario was assessed for technical feasibility, logistics, and economic viability through stakeholder interviews and techno-economic analysis.

**Scenario A (Centralized Swedish)** involves collection from dismantlers across southern Sweden, pre-processing at Stena Recycling Halmstad, and compounding at RondoPlast Ystad. The system handles 1 500 tons of input annually, producing 1 400 tons of automotive-grade pellets with 10% process losses.

**Scenario B (Distributed Regional)** establishes three regional hubs (Halmstad, Gothenburg, Norrköping) to reduce transport distances for bulky components. Processing 750 tons input yields 700 tons pellets with similar energy efficiency but 60% lower transport. However, CAPEX increases to 20-30 MSEK due to replicated infrastructure.

**Scenario C (Export to Germany)** utilizes existing specialist capacity in Germany. Swedish pre-processing is minimal (baling only), with 500 tons input producing 450 tons

OEM-certified pellets. While transport increases dramatically, CAPEX remains lowest at 4-5 MSEK.

Key technical findings include dismantling time averages 30 minutes per vehicle (verified by project partners), yielding approximately 30 kg recoverable plastic per ELV. Material flow capacity was verified at 1-2 tons/container for pressed parts and 20-24 tons/FTL for shredded material (project partners).

## Results

**Economic viability assessment** reveals significant challenges. Verified Swedish dismantling costs are 900 SEK/hour, resulting in 15 SEK/kg for the dismantling step alone. Total production costs range from 30-40 SEK/kg, while OEM willingness-to-pay remains around 15 SEK/kg (Volvo Cars input), creating an economic gap of approximately 15 SEK/kg.

**Logistics emerged as critical enabler or barrier.** Interview data confirmed that baling is essential for export scenarios—unpressed material achieves only 0.8-1.6 tons/container (€1,000-1,200 transport cost), while baled material reaches 20 tons/FTL (€1,000 transport). This 10-15x density improvement makes Scenario C economically viable despite long distances. Partner interviews revealed that automotive repair workshops handle 5x more plastic than dismantlers, representing an untapped volume source if container-based collection can be implemented. But due to the scope of the project and access to complete external data bases, this couldn't be verified.

**Stakeholder readiness varies significantly.** Larger dismantlers like JB Bildemontering and Eklunds (2 000-5 000 vehicles/year) possess necessary infrastructure but require clearer economic incentives. Additional project partners emphasized the need for "trustworthy actors delivering consistent quality", highlighting quality assurance as non-negotiable for automotive-grade output. Some feedback stressed that market timing is critical—with approximately one European recycler going bankrupt monthly in 2024-2025 due to low virgin plastic prices, but future ELV regulation implementation will reverse this to create material scarcity rather than demand shortage.

## Conclusions and deliverables from WP5

Three key barriers prevent immediate implementation of circular ELV plastic systems in Sweden:

1. **Economic gap of 15 SEK/kg between production costs and market willingness-to-pay. The time needed for dismantling and Swedish labor cost, making manual dismantling economically unviable without policy intervention or design-for-disassembly improvements.**

2. **Logistics infrastructure requirements differ by scenario.** Centralized systems (A) require tractor-press capability at dismantlers. Export scenarios (C) are entirely dependent on local baling service providers—without whom transport economics collapse. Regional systems (B) demand significant CAPEX (20-30 MSEK) for distributed washing/shredding facilities.
3. **Quality assurance chain requires industrial trust.** RondoPlast's requirement for pre-washed, sorted material and minimum 3-4 ton deliveries exclude small dismantlers from direct participation. This necessitates consolidation hubs but increases system complexity and coordination costs.

**Scenario C (Export to MOCOM) offers shortest path to implementation** due to lowest CAPEX (4-5 MSEK), leveraging existing OEM-certified capacity, and proven technology for contaminated ELV streams. However, long-term strategic autonomy favors building domestic capacity (Scenario A) once sufficient volumes justify investment. Scenario B represents a middle path suitable for regional pilots but requires multi-actor coordination that proved challenging during stakeholder workshops.

**Enabling factors for future viability** include: (1) EU ELV regulation enforcement creating demand pull, (2) OEM willingness to accept higher prices for certified circular content, (3) design-for-disassembly reducing manual labor time below 30 minutes per vehicle, and (4) integration of workshop collection streams

The "economic gap" identified in previous projects [The Sign, 2022] persists: while technical feasibility is demonstrated, business model viability requires either policy support (EPR schemes, recycled content mandates) or significant OEM price premiums beyond current 15 SEK/kg offers.

## **Environmental system analysis (WP 6)**

### **Performance**

In the CIRCUS project an environmental systems analysis and life cycle assessment of two case studies are performed. The first case study is based on WP4 and includes dismantling of three components (spoiler, door panel, B-pillar) and the reuse of recycled plastics into new vehicle components (re-manufacturing). The second case study is based on WP5 and includes the modelling of current and future system including dismantling, pre-treatment, recycled plastics and components manufacturing to the final vehicle components.

Case study 1: Dismantling and reuse of recycled plastic components from a value car.

Case study 2: Dismantling and recycling from dismantled to new vehicle components.

The environmental impact will be described per plastic, per component, and per car. Comparison between reuse of recycled plastics and potential for the Volvo car fleet and for the car fleet in Sweden. The environmental impact will also be linked to new requirements from the EU and the new ELV regulation.

The data collection from the CIRCUS project includes the following processes: Collection of plastics from crashed cars and end of life cars (10 + 20 years). The dismantling of car components and the sorting of plastic types. The cleaning and washing of components and plastic types. The storage of plastic components and plastic types. The logistics of plastics components and plastic types. The amount of plastic and types of plastics (PP-based and PC/ABS) in components and from cars (+10 and + 20 years).

The environmental data collection from the CIRCUS project includes the following:

- Plastic (kg) and recycled plastics (kg) and climate impacts (g CO<sub>2</sub>/kg)
- Energy use (kwh) and type of energy (g CO<sub>2</sub>/kwh) of processes included, such as collection, sorting, dismantling, cleaning, and storage
- Transport (km and g CO<sub>2</sub>/km) of collection and logistics

The data collection has been performed based on WP4 and with selected components. The selected components are the following: Spoiler (Rear spoiler), Door Panel (interior), and B-pillar (interior).

- The first component is a rear spoiler, commonly known as a wing, which is a key component of a car's aerodynamic kit. The weight of the rear spoiler is 0,4 kg including PC PET (22%) and PP GF 30 (25%) and PC/ABS (47%) and Metal (5%).
- The second component is a door panel that serves as an interface between the car's interior and is typically constructed from materials such as foamed cores covered with textiles or plastics. The weight of the door panel is 2 kg including ABS (15,6%), ABS GF 20 (44,4%), elastomer (27,6%), and other (ca 10%).
- The third component is the B-pillar and refers to the vertical structural support located between the front and rear doors of a vehicle and is responsible for rollover requirements. The weight of the B-pillar is 1,96 kg including PC/ABS (68,5%) and PET (11%) and ABS (11,6%) and other materials (ca 10%).

The data collection has been performed based on WP5 and is based on three systems. The current system is Scenario A, where existing partners and transport are included. The future system includes Scenarios B and C, where pre-treatment is performed in regional Hubs in Sweden or exported in already established operation.

The processes and companies modelled in the three chosen system include: Dismantling (plastic collection, dismantling and cleaning), pre-treatment (sort, shred, metal, sink float, wash/dry), Recycled Plastics (grinding, compounding, pelletizing), components manufacturing, final plastic component (Volvo Cars).

The data collection for the techno-economic analysis in WP5 has been updated and complemented with a span of personal costs for dismantlers (based on car insurance) and a span of plastic prices (based on plastic manufacturers) and literature on existing machinery for recycling of plastics as well as a complete recycling line (baling, shredding, washing, compounding).

## Results

The results for the first case study (Reuse of recycled plastics) and the three components:

- 65% reduced kgCO<sub>2</sub>/kg recycled PP and 32% per component (spoiler).
- 68% reduced kg CO<sub>2</sub>/kg recycled ABS and 41% per component (door panel).
- 49% reduced kg CO<sub>2</sub>/kg recycled ABS and 35% per component (B-Pillar).

The additional impact categories (reduced plastics) show the following:

- Reused plastics = 0% to 48% (Spoiler) or 61% (Door Panel) or 70% (B-pillar)
- Reduced waste = 100% to 52% (Spoiler) or 39% (Door Panel) or 30% (B-pillar)
- Recycled plastics = 0,188 kg (Spoiler), 1,22 kg (Door Panel), 1,37 kg (B-pillar)
- Reused and reduced need of new plastics and reduced waste and incineration

Additional circular impact categories show the following:

- Increased reuse content of recycled plastics and components
- Increased recycling content of recycled plastics and per component

The LCA results for the second case study (closed loop flows of recycled plastics) and the three systems show the following: The energy used in the three systems is based on dismantling, sorting and pressing, Krossing and metal, washing and drying, as well as compounding and pelletizing. Scenario A and B show similar results for the three HUBs. Scenario C and Scenario C (alt) show 2-3 times higher results due to the European energy mix (kg CO<sub>2</sub>/kg). The energy use is based on Nordic Electricity mix and Swedish Electricity mix. When using green electricity, such as wind energy, carbon emissions are reduced by 50% compared to Swedish El-mix and more than 90% compared to EU mix.

Table 10. The transport used in the three systems is based on the following:

<b>Scenario A:</b> Jönköping → Halmstad → Ystad → Göteborg
<b>Scenario B:</b> Norrköping/Jönköping/Halmstad → Ystad → Göteborg
<b>Scenario C:</b> Jönköping → Mocom (Gardelegen → Hamburg) → Göteborg
<b>Scenario C:</b> Jönköping → Mocom (Gardelegen → Zülplich → Hamburg) → Göteborg

The results in Scenario A and B show similar results for the three HUBs. The results in Scenario C and Scenario C (alt) show 2-3 times higher results due to transport distance.

The results from the three systems (Sweden and Germany/Europe) are compared with virgin plastic transported from China. The total results for the three systems including energy for dismantling and recycled and transport and final component show a reduction potential of 20-30%.

The updated techno-economic analysis shows that the personal costs and the scale of investments are important for the future open loop recycling system.

- Scenario A-C: 10-15 SEK/kg for personnel cost and (600-900 SEK/kg)

The results of the techno- economic analysis include CAPEX (Update):

- Scenario A: 0,7 - 7 MSEK include a new washing line.
- Scenario B: 2-20 MSEK include a new complete recycling line (scale).
- Scenario C: 0,5-1,5 MSEK include a new shredding and baling machine.

The results of the techno- economic analysis include PRICE (Update):

- Scenario A-C: 15 SEK/kg for virgin plastic
- Scenario A-C: 15-20 SEK/kg for PP and depends on quality and process
- Scenario A-C: 20-25 SEK/kg for PC/ABS and depends on quality and process

### **Conclusions and deliverables from WP6**

The first case study (Reuse of recycled plastics) and the three components are compared: While the reduction potential for climate emissions and recycled plastic is high (49-68%), the reduction potential per component is lower (32% - 41%). The reduction potential depends on the quality and the processes involved. The reduction potential depends also on the possibility to recycle mixed plastics.

The second case study (closed loop flows of recycled plastics) and the three systems are compared with virgin plastic transported from China. The results for the three systems including energy for dismantling and recycled and transport and final component show a reduction potential of 20-30%.

The updated techno-economic analysis shows that the personal costs and the scale of investments are important for the future open loop recycling system. While large scale investment is not beneficially, the small-scale investment is better and give a small profit range for PP and a better range for PC/ABS.

The availability of plastics in demolished cars and the demand of plastics in new cars: The demolished cars have decreased from 180 000 to 120 000 in 2024. In Southern there are 86 900, which means 2 607 tons of plastics if all cars are dismantled.

The demand of plastics in new cars is increasing. Around 75-80% need to be collected to meet a starting capacity of 2 000-ton plastics in Sweden, while around 7000 ton/year are possible in Europe/Germany.

Collecting 30kg plastics per ELV car corresponds to 16% based on 186 kg Plastic (Volvo XC40) and 7,7% based on 390kg Plastic (Volvo EX90). New ELV directive is fulfilled (ELV 6,25%). However, the demolished cars are not enough for upscaling: 763 389 Volvo Car Fleet or 270 000 cars in Sweden or 10 802 000 cars in Europe.

## **5. Deliverables and contribution to the goals**

The results, conclusions and deliverables are compiled with the work packages described in this section. The deliverables from the project are well in line with the goals of the project. But the partner Polestar in United Kingdom unfortunately had to closed down in the autumn of 2025. Polestar had planned to make a CAD model of a re-designed door panel within WP4 but it could not be done due to the circumstances. Also, Volvo Cars carried out a major reorganization in 2025 that reduced their involvement in the project for some time. The deliverables of the project are here compared with the goals of the FFI Program Circularity and the general goals of the FFI Program:

***The deliverables of the project contributes to the FFI sub program Circularity as follows with new knowledge and solutions to enable circular use of automotive plastics:***

- The project has generated knowledge exchange among actors across the entire value chain and established a constructive climate for collaboration which is crucial for development of effective circular material recycling systems from ELVs to new vehicles.
- Based on the car models dismantled, the project has identified which plastic components are best suited for dismantling and material recycling.
- Picklists and best practise solutions developed for dismantling and cleaning of the plastic components are essential for efficient processes and recycling of the plastics.

- Knowledge of the plastics composition in various car models and which of the plastics are best suited for circular recycling.
- Knowledge of good sorting procedure for plastics recycling.
- Knowledge of the material properties of ELV plastics recovered from 5, 10 and 20 year old cars is essential for the recycler and manufactures of automotive components.
- The design guidelines developed support the designers in the automotive industry and can contribute to circular design and enable recycling of the plastics.
- Circular redesign guidelines and re-construction proposals for a door panel, a B-pillar and a rear-spoiler support the designers in the automotive industry and can contribute to circular design and enable recycling of the plastics.
- New knowledge of recycling processes useful for automotive plastics, the possibilities and the limitations with the processes and improvements needed is also an important delivery to enable circular recycled automotive plastic.
- The project partner Marcus Schill at Plasman, leader of work package 4, has been part of the work in an European standardisation group developing the standard SIS-CEN/TD 18084:2025 Post Shredder Technology recycling – Design recommendations for plastic products. The standard will help designers of automotive components to design and select materials that enable recycled in a technical and economically feasible way.
- Contribute with a system perspective on circular business.
- Contribute to environmental savings due to avoided CO2 emissions from incineration of automotive plastics and avoided CO2 emissions when recycled plastics replaces part of the virgin plastics in automotive.

***The project deliverables with new knowledge and solutions contributes to the FFI program in general as follows:***

- Strengthen Sweden's automotive industry while contributing to knowledge and solutions needed to the transition towards sustainable use of resources and circular use of plastics.
- Contribute sustainable manufacturing and recycling of automotive plastics in Sweden.
- Contribute to enable the Swedish automotive industry to meet the new ELV regulation coming, the demands on recycling of ELV plastics and demands on use of circular recycled ELV plastic in new vehicles.

## 6. Dissemination and publications

The project results are of significant value to the automotive industry and all actors within the circular value chain in the transition towards sustainable circular use of plastics. However, there is still much work needed before circular recycling of automotive plastics can be implemented in Sweden.

### 1.1 Dissemination activities

- Volvo Cars sent out a press release about the project starting up in November 2024
- Information on LinkedIn when the project was started up (January 2024)
- Project website published
- Presentation on a Network meeting arranged by National Centre for Sustainable Plastics 15 august 2024.
- Presenting the project at a member meeting of the Danish “Plastindustrien” 24 September 2024.
- Meeting with the steering group of the Danish RACE project.
- Taking part in the reference group of the FFI project, the Circular Car. Knowledge exchange between the projects has added valuable new perspectives for both projects.
- Presentation the project and results at the Net Zero Industry Manufacturing R&D Cluster Conference in Gothenburg the 14 May 2025
- Presentation the project and results at Stena Recycling in Halmstad 27 August 2025.
- Meeting with the project team of the Danish RACE project, exchanging experiences from the project.
- Presentation project and results at the conference the Circular Plastic, arranged by RISE, National Centre for Sustainable Plastic, 4 June 2025. Project partners from Volvo Cars and Artifex Systems (ex. IAC) were together with RISE taking part in a panel discussion at the conference.
- The project team of CIRCUS arranged 29 of January 2026, a Seminar at RISE in Mölndal, where the results from the project were presented. It was an open seminar, and everyone interested could take part either IRL or online.
- All the partners spreads information and results from the project within their organizations and networks.

### 1.2 Publications

Project reports from work packages 1, 2 and 6.

## 7. Conclusions and future research

### Conclusion summary

The project confirms that the reuse of plastic automotive components already functions effectively as a business model, driven by strong market demand. Insurance companies play an important role by requiring the reuse of parts for economic reasons, while also contributing to increased sustainability. In parallel, there is a clear trend towards extending vehicle lifetimes, further strengthening the reuse market.

The dismantling studies demonstrate that many plastic components can be dismantled efficiently using existing methods. However, the results are strongly influenced by factors such as component selection, vehicle age and condition, component design, and fastening solutions. Under favourable conditions, it is realistic to achieve the target of dismantling 30 kg of recyclable plastics within 30 minutes per vehicle, although feasibility varies significantly between different car models.

The project confirms that the majority of plastics in vehicles are polypropylene (PP)-based and, in principle, well suited for mechanical recycling. However, large components such as bumpers are typically painted, which poses challenges for recycling, as paint residues negatively affect the quality of the recycled material. Addressing paint removal and contamination remains a key challenge for high-quality closed-loop recycling.

Dismantling of plastic components shows strong potential as a foundation for circular recycling and the production of new automotive components. To scale this approach effectively, standardisation, high operational efficiency, and strong coordination and leadership across the value chain are required.

Material characterisation results indicate that plastics recovered from ELV vehicles that are 10 and even 20 years old retain surprisingly good properties, particularly PP-based materials. With a coordinated and motivated value chain, these materials have the potential to meet the automotive industry's strict technical, quality, and delivery requirements and could become a competitive circular resource.

Recycling feasibility studies for three component systems—the rear spoiler, the B-pillar, and the door panel—show that recycling rates of up to 80% are realistic for the rear spoiler and B-pillar if redesign measures are implemented. In contrast, the door panel represents a highly complex system with many different materials that are often glued together. From an economic perspective, recycling of door panels is challenging, as material losses become high and cost efficiency is low.

A central question addressed in the project is whether the Swedish automotive industry can meet the upcoming ELV regulation requirements to recycle 30% of plastics from each ELV vehicle and to use 6.25% circular recycled plastics in new vehicles. The analysis indicates that achieving a 30% recycling rate may be possible, but meeting the requirement for 6.25% ELV-based recycled plastic in all new vehicles produced in Sweden is unlikely if the recycled material is limited to ELV vehicles scrapped domestically. In 2024, approximately 160,000 cars were scrapped in Sweden, corresponding to about 4,800 tonnes of recoverable plastic if 30 kg per vehicle is assumed. In comparison, Volvo Cars alone produced 456,250 vehicles in Sweden and 708,716 vehicles globally in 2023, requiring approximately 7,118 tonnes of circular recycled plastics for Swedish production and 11,056 tonnes globally. Notably, the most recent version of the ELV proposal has reduced the required share of circular recycled plastics.

Finally, the techno-economic analyses show that labour costs and investment scale are critical factors for future open-loop recycling systems. While large-scale investments are not economically feasible under current conditions, small-scale investments may be viable, with a limited profit potential for PP-based materials and a more favourable economic outlook for PC/ABS systems.

### **Further work**

Significant research and development efforts are still required across the entire automotive value chain before large-scale circular recycling of plastics from end-of-life vehicles (ELVs) can be realised in Sweden. Many technical and economic challenges remain, and addressing these will demand close collaboration between OEMs, dismantlers, recyclers, material suppliers, and component manufacturers. The following areas are identified as key priorities for future work:

- **Validation and refinement of dismantling procedures:** The dismantling procedures defined in the model-specific picklists need to be tested, validated, and further refined in operational dismantling workshops.
- **Standardised dismantling, cleaning, and sorting routines:** Consistent routines for dismantling, cleaning, and sorting must be developed, tested, and evaluated to ensure efficiency, quality, and reproducibility across different dismantling environments.
- **Development of suitable washing methods:** Washing processes for dismantled plastic components require further development, with assessments of cleaning efficiency, cost, environmental impact, and compatibility with downstream recycling processes.

- **Advancement of recycling processes:** Further optimisation is needed in plastic blending strategies, material separation, paint removal, feeding into the compounder, compounding, additional processing steps including degassing, melt filtration, and upgrading of the ELV plastics with additives to improve material properties and processability.
- **Material characterisation:** Recovered plastics must be comprehensively characterised regarding purity, mechanical and processing properties, to ensure suitability for automotive applications.
- **Long-term performance testing:** Ageing testing of ELV-derived plastics are required to verify whether recyclates can meet automotive requirements over time and to identify necessary upgrading steps.
- **Development of ELV-based compound formulations:** Compounds based on ELV plastics must be formulated to meet automotive material and performance specifications, including requirements for processability and long-term durability.
- **Pilot-scale validation:** Pilot-scale processing should be conducted to demonstrate that ELV-based materials can meet existing specifications for automotive plastics and components.
- **Component-level validation:** Automotive components should be manufactured using circular ELV plastics and evaluated to verify compliance with relevant technical, quality, and durability standards.
- **Recycling routes and logistics:** Further investigation of recycling routes, logistics systems, associated costs, and environmental impacts is needed to support scalable industrial implementation.
- **Broader engagement across Sweden:** A wider involvement of dismantlers and workshops is necessary to assess the feasibility of dismantling according to picklists, cleaning procedures, and plastic sorting. Parallel evaluations of recycling routes, logistics, costs, and environmental impacts are needed in a broader industrial context.

## 8. Participating parties and contact persons

Partners in the projects:



Several persons from the partner organizations have participated in the project work. Below is a list of one contact person from each partner organization.

Table 11. Project partners and one contact person per partner.

Company	Contact persons	E-mail
Mocom	Stefan Vellekoop	stefan.vellekoop@ottokrahn.group
Volvo Cars	Tom Engblom	tom.engblom@volvocars.com
Polestar	Rachel Holland	---
Plasman	Marcus Schill	marcus.schill@plasman.com
Artifex Systems	Markus Akervall	markus.akervall@artifexautocomp.com
KB Components	Andreas Ullman	andreas.ullman@kbcomponents.com
RondoPlast	Anette Munch Elmer	Anette.MunchElmer@polykemi.se
Stena Recycling	Marianne Gyllenhammar	marianne.gyllenhammar@stenarecycling.se
Jönköpings Bildemontering	Simon Dahl	Simon.dahl@jb-bildemo.se
Walters Bildelar	Anders Mobjer	anders.mobjer@waltersbil.se
Eklunds Bildelslager	Linnea Eklund	linnea.eklund@eklunds.se
BASF	Peter Klarqvist	peter.klarqvist@basf.com
Sveriges Bildemonterares Riksförbund	Andreas Frössberg	andreas.frossberg@sbrservice.se
Bilretur	Carina Hagström	carina.hagstrom@bilretur.se
Mobility Sweden	Anna Henstedt	anna.henstedt@mobilitysweden.se
RISE	Annika Boss	Annika.boss@ri.se